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R-8842

TECHNICAL MANUAL

MAINTENANCE AND SUPPORT PLAN

FOR SATURN F-1, H-1, AND J-2

ROCKET ENGINES

DRA

(ROCKETDYNE)

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INTRODUCTION

Rocketdyne, a Division of Rockwell International, under contract to the National Aeronautics and Space Administration (NASA), provides support for Saturn Vehicle (1B and V) F-1, H-1, and J-2 engines.

This plan defines the support requirements for Saturn engines and support equipment in the Saturn resources program and the Apollo Soyuz Test Project (ASTP) to: (1) maintain personnel capability during periods of stage/engine storage, (2) maintain flight hardware current, (3) maintain unassigned hardware (engines, GSE, spares, etc) in a condition to preclude hardware deterioration, and (4) minimize change to existing data systems (manuals, reports, inventory control, etc).

Deviation from the concept of this plan must have NASA approval. If a conflict between this plan and the engine contract occurs, the contract shall prevail.

SECTION I

PROGRAM SUPPORT ORGANIZATIONS

1.1 GENERAL.

This section identifies the Rocketdyne Saturn engine and support equipment program support organizations (figure 1-1). These organizations, under the direction of the Saturn program manager, will maintain the Saturn engines and support equipment in condition to support the Saturn resources program and the Apollo Soyuz Test Project (ASTP).

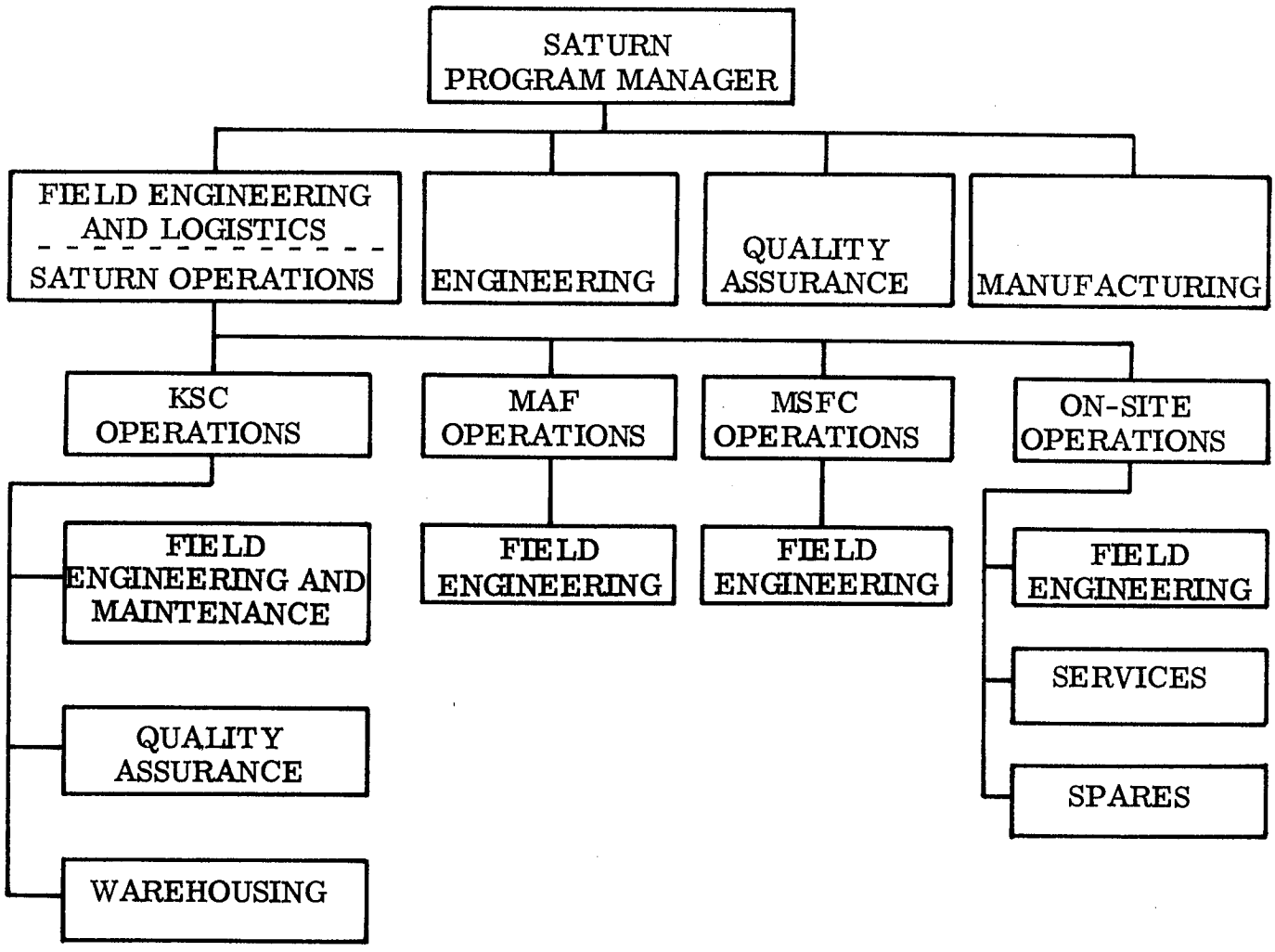

Figure 1-1. Program Support Organizations

SECTION II

SUPPORT APPROACH AND RESPONSIBILITES

2.1 GENERAL.

This section describes Rocketdyne's approach for providing the various support elements essential to maintaining the condition of unassigned Saturn hardware and for processing ASTP assigned Saturn stages for launch. This section also lists responsibilities of the participating Rocketdyne support organizations (specified in section I) in implementing the approach. Specific requirements for accomplishing significant support activities are described in subsequent sections.

2.2 SUPPORT APPROACH.

Rocketdyne's support approach is based on the following ground-rules:

a. S-II and S-IVB stages are stored at KSC.

b. S-IC stages are stored at MAF.

c. S-IB stages are stored at MAF and KSC.

d. Flight spare and flight worthiness verification (FWV) engines are stored at KSC and MAF.

e. GSE required for H-1 and J-2 engine repair, system reverification and checkout, component replacement, and spare hardware periodic retesting is at KSC.

f. F-1 GSE and T-tools are stored at KSC and EFL.

g. Spare hardware for planned operations is at KSC.

h. Dormant spare hardware assets are stored at EFL.

i. F-1 Thermal Insulation Sets (TIS) are stored at MAF.

2.2.1 PERSONNEL, SKILLS, AND TRAINING.

Rocketdyne has analyzed the work to be done and determined the technical and administrative tasks to be performed. Based on this analysis, and after considering the individual's ability to work under varying degrees of stress, work conditions, and environment, Rocketdyne has assigned people to the specific organization that requires that individual's particular skill.

To ensure that knowledge, skills, and motivation are maintained at a high level during periods of infrequent task performance, a program of skill exercises and training has been planned. The program provides for skills recertification, problem solving exercises, task simulation, task briefings and demonstrations, system reorientations, and motivational training.

Skill and training program activities are scheduled and coordinated for Rocketdyne personnel through the Rocketdyne Field Managers and/or Saturn Operations at Canoga Park. Training courses are scheduled and coordinated for NASA and stage contractor personnel through the Saturn Engine Project Office at MSFC.

2.2.2 TECHNICAL PUBLICATIONS.

The technical publications prepared by Rocketdyne for Saturn field use are based on the more extensive maintenance concepts and capabilities in effect during the Apollo/Skylab programs. Although this provides more procedural information than is currently required, the data will not be updated to delete the information. As a result, the existence of a specific repair procedure

in an engine repair manual does not reflect authority to perform the repair at the site. The maintenance section and tables in this maintenance and support plan must be referred to for the scope of permissible engine and component repairs.

Technical publications and their source data are monitored to ensure that the technical publications are current. Changes, revisions, and supplements are issued to meet field needs for up-to-date information. A single release of updated information is scheduled in time to support removal of ASTP assigned stages from storage; preparation and distribution will be delayed until then unless there is a prior urgent requirement for specific data.

2.2.3 SPARES.

Support hardware selections have been made based on maintenance concept, task analysis, failure and consumption data, and number of sites supported. The component usage data and overhaul history from prior contracts has been thoroughly analyzed to predict future hardware usage. As a result, enough spare hardware has been acquired to support the anticipated needs of the planned Saturn activity.

Procedures for repair, overhaul, servicing and/or modification of reparable items returned to Canoga Park are developed in conjunction with the Purchasing and Manufacturing departments. Procedures for procuring additional support hardware items or other servicing effort for hardware returned from the field sites are contractually established with NASA; however, support for the ASTP program will normally encompass component removal and replacement with no repair of the replaced item.

All flight spare components are warehoused at KSC with the exception of ordnance. One flight set of ordnance is stored with test samples at KSC. Remaining ordnance is stored at Rocketdyne's Santa Susana Field Laboratories.

F-1 spare hardware is placed in a "resource holding" status with no periodic retesting planned. H-1 and J-2 components with periodic retest requirements are retested at KSC and Canoga Park, depending on local capabilities.

2.2.4 FIELD SITE ENGINEERING, MAINTENANCE, AND QUALITY ASSURANCE.

Field Engineering is provided to NASA, stage contractors, and the vehicle integration contractor at MSFC, MAF, and KSC. The primary function of the field engineers is to provide an on-the-spot interface between manufacturer and user for technical assistance and problem resolution.

In addition to Field Engineering, maintenance and quality assurance support is provided at KSC. The maintenance and quality assurance personnel provide the special skills that are essential to reliable preventive and corrective maintenance. When necessary, on site skills are supplemented by sending Canoga Park personnel to KSC on a trip basis.

When a stage is removed from storage and processed at MAF, a Rocketdyne team of technicians and inspectors is dispatched to that location to provide the maintenance and quality assurance functions. Details of the Rocketdyne-Stage Contractor interface for maintenance and quality assurance are in section III. The method of documenting field operations for control and quality assurance tracking is described in section VI.

Details of the Saturn engine maintenance concept are described in section IV. However, because of changing program scope and reduction in total program facilities, the maintenance concept has been evolutionary. Important features of the current method of operation are:

- Corrective maintenance primarily done on-the-vehicle, and generally by removing and replacing components.

- Some thrust chamber weld repairs and limited turbopump disassembly is permissible for in-place repair.

- Discrepant components are replaced with spares. The removed units are not repaired, but failure analysis may be performed.

2.3 RESPONSIBILITIES OF SUPPORT ORGANIZATIONS.

2.3.1 FIELD ENGINEERING AND LOGISTICS SATURN OPERATIONS.

Saturn operations is the communications medium among NASA, stage contractors, Rocketdyne management, and between field site and home office organizations for coordinating significant program changes, solving technical problems, and implementing support requirements affecting the Logistics support. Program milestones and requirements are communicated to Logistics field site and home office support elements, so that total product support is provided at NASA and stage contractor assembly, test, and launch facilities. The budget, technical, and support task effectiveness of Logistics support elements is continuously reviewed and measured to make sure Logistics goals and commitments are fulfilled.

2.4 FIELD SITES.

Field site operations are conducted at KSC, MAF, and MSFC. Field operations personnel, under direction of Field Engineering and Logistics Saturn operations, are responsible for supervising, monitoring and troubleshooting all events that may affect Rocketdyne delivered products.

2.4.1 KSC OPERATIONS.

KSC Operations, comprised of engineering and maintenance, quality assurance, and warehousing, is responsible for providing support to NASA and stage contractors. Specific functional responsibilities are as follows:

a. Field Engineering and Maintenance:

(1) Support NASA and the stage contractor in stage/engine assembly and storage, integrated system tests, and vehicle launch operations.

(2) Review field procedures.

(3) Perform engine and GSE component maintenance, repair and testing.

(4) Perform engine and GSE modifications.

(5) Participate in stage/engine reviews.

(6) Evaluate checkout, test, and flight data.

(7) Coordinate interface with stage contractor.

(8) Prepare and approve work documentation for engine maintenance and modification.

b. Quality Assurance:

(1) Enforce quality assurance requirements.

(2) Review and approve work documentation.

(3) Monitor stage contractor engine-associated work.

(4) Inspect spare hardware.

(5) Inspect component testing.

(6) Enforce safety requirements.

c. Warehousing:

(1) Inspect, document, and store material received.

(2) Coordinate selection of support parts.

(3) Provide support hardware consumption data.

(4) Maintain shelf-life surveillance of applicable hardware.

(5) Coordinate repair and recycle of components.

(6) Maintain support parts accountable stock records.

(7) Prepare documentation for shipping GFP.

(8) Prepare and process documentation for disposal of excess and residual property.

(9) Perform periodic inventories.

(10) Maintain preservation and servicing records of equipment in storage.

(11) Receive, stock, ship, and maintain support hardware with necessary documentation.

(12) Perform cyclic and special inventories as requested.

2.4.2 MAF OPERATIONS.

MAF Operations, comprised of field engineering, is responsible for providing engineering consultation to NASA/Chrysler Corporation Space Division at MAF in support of H-1 engine operations and S-1C stage and F-1 engine storage.

2.4.3 MSFC OPERATIONS.

MSFC Operations, comprised of field engineering, is responsible for providing engineering liaison to NASA in support of Saturn engines and related support equipment.

2.5 HOME OFFICE

Home Office Operations is responsible for providing backup support to the field sites. Field Engineering and Logistics backup operations is comprised of Field Engineering, Services, and Spares. Rocketdyne Canoga Park backup operations is comprised of Engineering, Quality Assurance, and Manufacturing.

2.5.1 FIELD ENGINEERING AND LOGISTICS BACKUP OPERATIONS.

2.5.1.1 ENGINEERING. Home Office Saturn Operations Engineering is responsible for coordinating all support elements and is the communications link between field sites and Canoga Park. Specific functional responsibilities are:

a. Access and resolve technical problems.

b. Coordinate vehicle/engine interface.

c. Identify field requirements.

d. Prepare field activity and status reports.

e. Determine program support requirements.

f. Provide technical support and administrative direction to Field Site Operations personnel at all field locations.

g. Make sure support requirements fulfill contractual commitments and objectives.

h. Prepare Field Operation Requirement & Record forms on all work done on GFP at Canoga Park and EFL.

i. Maintain H-1 and J-2 program historical data and retrieve as required to support ASTP.

j. Coordinate quality assurance procedures with field site personnel.

k. Provide specialized maintenance support.

2.5.1.2 SERVICES. Services, comprised of Support Engineering, Publications, and Training is responsible for support of field sites as required. Specific functional responsibilities are as follows:

a. Support Engineering:

(1) Analyze maintenance concepts.
(2) Perform maintenance and task analyses.
(3) Analyze maintenance and support operations.
(4) Develop program and maintenance plans.

b. Publications:

(1) Define field support data change requirements.
(2) Prepare technical procedures and instructions.
(3) Coordinate technical data and source information.
(4) Prepare and maintain configuration data.
(5) Publish field support data.

c. Training:

(1) Analyze training requirements.
(2) Develop training programs.
(3) Prepare training aids.
(4) Prepare training materials.
(5) Provide training.

2.5.1.3 SPARES. Spares, comprised of Management and Warehousing is responsible for support of the Saturn resources program and the Apollo Soyuz Test Project. Specific functional responsibilities are as follows:

a. Manage support hardware program.

b. Provision spare parts.

c. Receive and process hardware.

d. Maintain master support hardware records.

e. Stock parts and equipment.

f. Package and ship hardware and materials.

g. Process, store and/or dispose of excess hardware.

h. Monitor and control inventory.

2.5.2 ENGINEERING. Engineering, comprised of Engine Systems, Component Reliability, Materials and Processes, Packaging, and Metallurgy is responsible for support of the Saturn resources program as requested and the Apollo Soyuz Test Project. Specific functional responsibilities are as follows:

a. In conjunction with Field Engineering and Logistics, resolve Saturn engine problems.

b. Administrate Unsatisfactory Condition Report (UCR) and Failure Analysis Report (FAR) system.

c. Review and evaluate procedures, specifications, and interface control documents in support of stage/engine checkout and testing.

d. Review drawing change requests, stage contractor Engineering Change Proposals (ECP) and drawings, and other NASA/stage contractor data that may impact engine requirements.

e. Provide current overhaul and component repair and servicing test specifications and requirements.

f. In conjunction with Saturn Operations analyze and evaluate flight data to compare engine performance with flight predictions.

g. Participate in Flight Readiness Reviews (FRR), vehicle Flight Readiness Tests (FRT), vehicle Countdown Demonstration Test (CDDT), and vehicle launch operations.

2.5.3 MANUFACTURING.

Manufacturing is responsible for component retest and repair as requested by Spares.

2.5.4 QUALITY ASSURANCE.

Specific functional responsibilities of quality assurance at Canoga Park in support of the Saturn resources program and the Apollo Soyuz Test Project are as follows:

a. Quality assurance policy and guidance.

b. Identify field inspection requirements.

c. Coordinate with Field Engineering and Logistics backup operations to make sure quality assurance inspection requirements fulfill contract responsibilities.

SECTION III

FIELD SITE OPERATIONS

3.1 GENERAL.

This section outlines and describes the support activities at field sites (figure 3-1) where Rocketdyne engines and support equipment are located. These activities include support effort associated with Saturn engines, engine interface responsibilities, launch vehicle operations, personnel safety, and field site deactivation effort. Field Site Operations support is provided at the following sites:

- Michoud (MAF) - S-IB and S-IC Stage storage.
- Kennedy Space Center (KSC) - Saturn V and IB Vehicle Launch Operations and Flight Stage storage.
- Marshall Space Flight Center (MSFC) - NASA Program Management and engine systems testing.

3.2 FIELD ACTIVITY.

Field Site Operations personnel at each field site perform major field support activites (specified in section II) associated with maintaining engines, GSE, and support hardware in a serviceable condition during the normal stage/vehicle operational flow. Rocketdyne/stage contractor relationship and responsibilities for interface activities are in Joint Operating Agreements (table 3-3), prepared and approved on-site.

3.2.1 KSC SUPPORT ACTIVITIES.

Support activities at KSC include, but are not limited to, the following:

a. Participate in daily work schedule planning actions.

b. Assist stage contractors by reviewing stage/engine checkout and launch procedures.

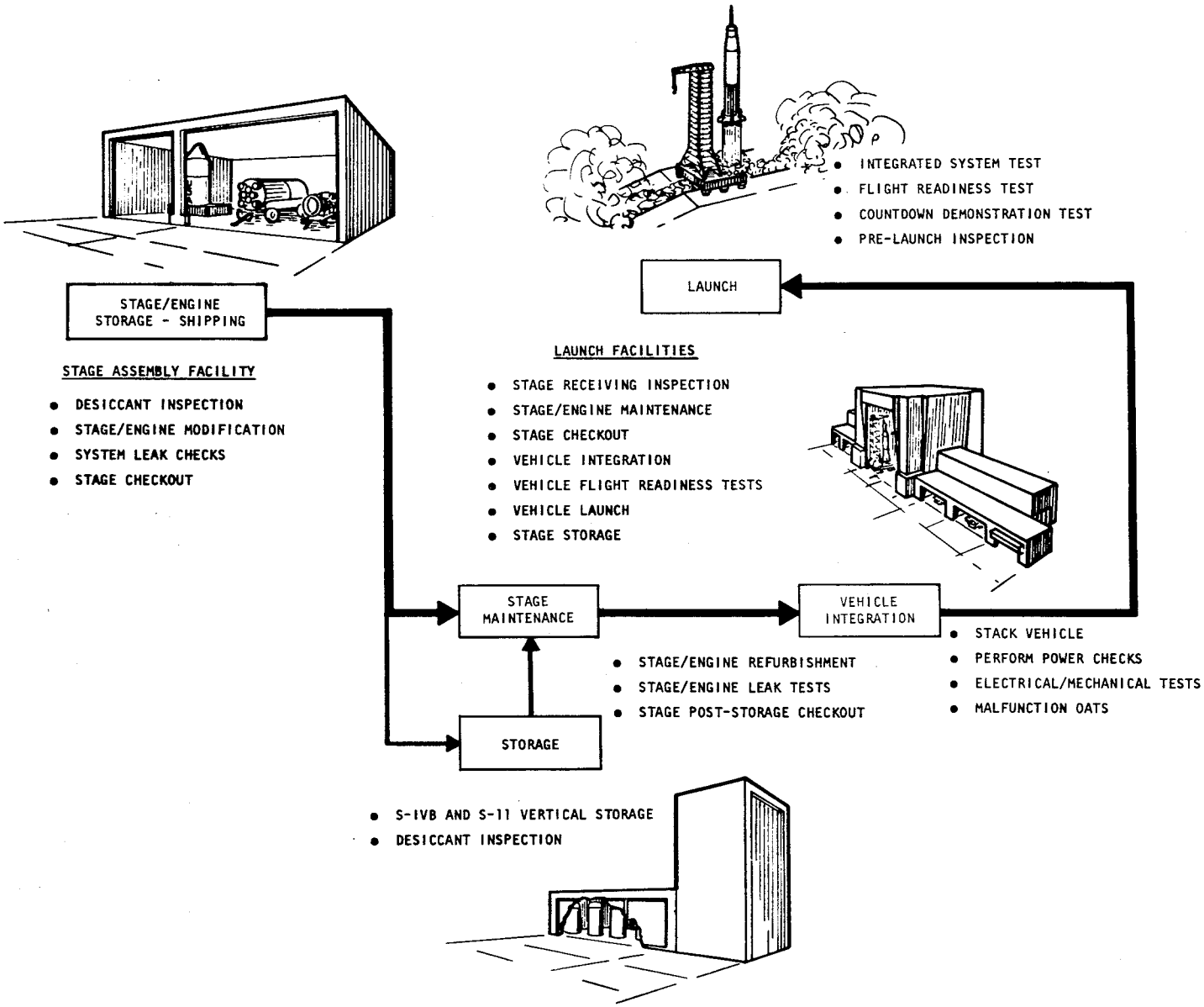

Figure 3-1. Saturn Engine and Stage Flow

Tables 3-1 and 3-2 deleted.

Table 3-3. Joint Operating Agreements

KSC

1. Joint Operating Agreement for Rockwell International Space Division/Launch Operations and Rockwell International Rocketdyne Division at Kennedy Space Center - S-II Stage and J-2 Engine.

2. Joint Operating Agreement for McDonnell Douglas Astronautics Company and Rockwell International Rocketdyne Division at Kennedy Space Center - S-IVB Stage and J-2 Engine.

c. Review and comment in writing to resident NASA Engine Project Office Representative on stage contractor procedures associated with engines and GSE. (See figure 3-2.)

d. Participate in all preshipment and flight readiness reviews.

e. Analyze prelaunch checkout and flight data to verify engine operation and performance.

f. Help stage contractor prepare flight evaluation reports to NASA.

g. Prepare Field Operation Requirement & Record (FORR) forms on all work done on Rocketdyne hardware by Rocketdyne personnel.

h. Perform maintenance, checkout, and inspection on components, engines, and GSE in accordance with approved documentation.

i. Perform engine and GSE modifications and special inspections in accordance with approved ECP modifications and EFIR instructions.

j. Install loose equipment on engines per joint operating agreements.

k. Install, remove, and replace engine closures, covers, test plates, throat plugs, and engine or GSE associated test equipment.

l. Help stage contractor leak check engine systems.

m. Participate in stage/engine systems checkout to verify engine integrity.

n. Provide quality assurance surveillance for engine and engine associated tasks.

o. Perform quality assurance review and identify mandatory inspection points on the FORR.

p. Perform special engine systems and subsystems inspections due to checkout operation anomalies or as required by EFIR instructions.

q. Maintain engine and GSE configuration control and maintenance records. Prepare Engine Log Book change sheets and distribute to stage contractors. Review entries in Engine Log Books for accuracy.

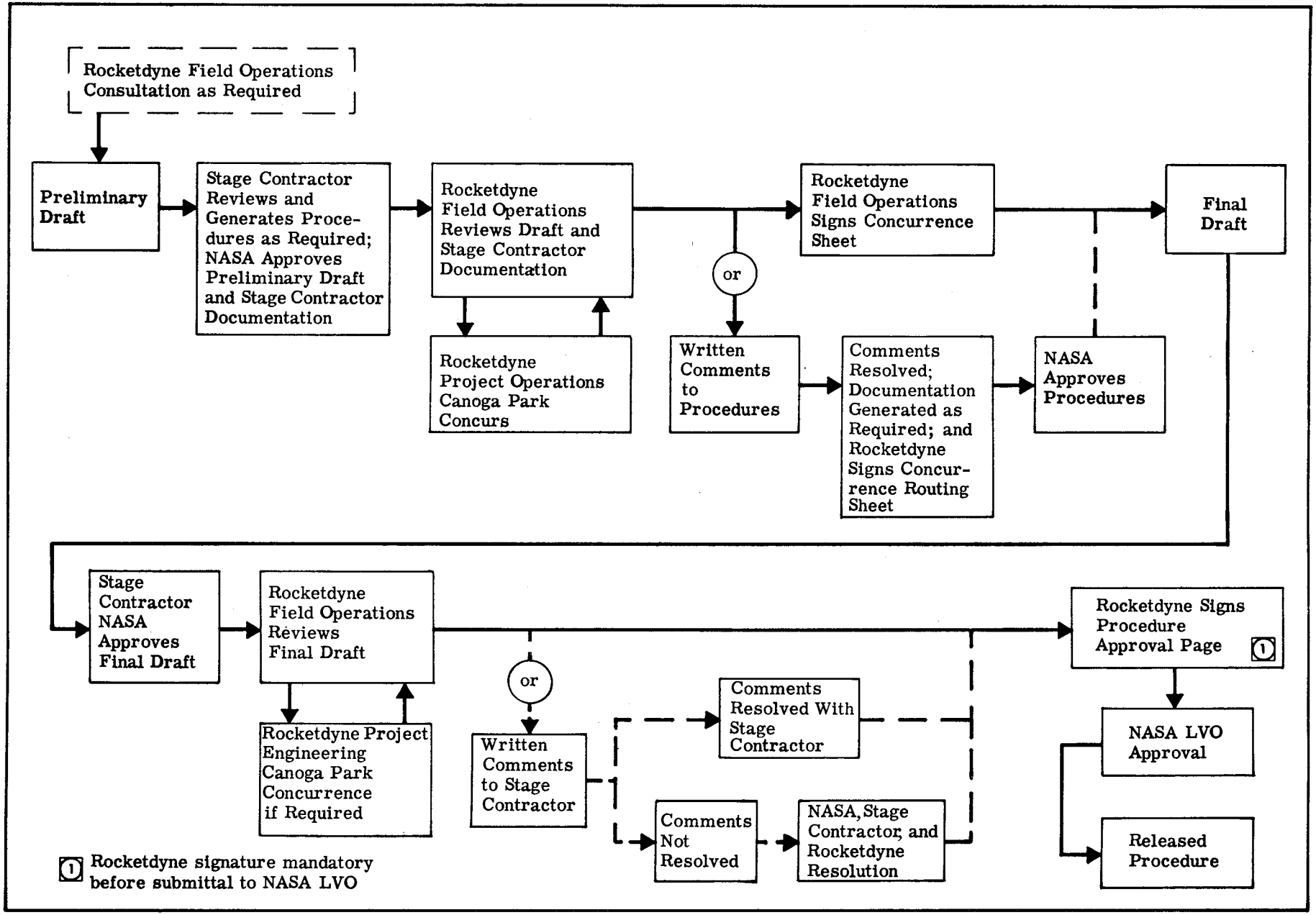

Figure 3-2. Rocketdyne Review of Stage-Oriented Engine Checkout Procedures at KSC

r. Provide NASA with Rocketdyne recommendations for disposition of discrepant engine and GSE hardware.

s. Initiate necessary action to clear engines and GSE discrepancies.

t. Remove, reinstall, repair, service, test, and maintain integrity of delivered engine systems.

u. Prepare UCRs on failed or discrepant engine hardware and spare components.

v. Modify spare components in accordance with Request for Disposition approved by resident NASA Engine Project Office Representative and Contracting Officer Representative at Rocketdyne, Canoga Park.

w. Retest spare components as prescribed by support hardware and program planning documentation or return components to Canoga Park for retest.

x. Provide spare support hardware for delivered engines and GSE from a Rocketdyne managed and operated GFP warehouse.

y. Coordinate spares inventory required to support maintenance operations at KSC.

z. Maintain inventory control records of engine and GSE support hardware.

aa. Help checkout and proof test GSE assigned to stage contractor.

ab. Coordinate periodic proof-loading of GSE, proof-testing of flex hoses, and calibration of gages, meters, tools, and test equipment assigned to Rocketdyne.

3.2.2 MAF SUPPORT ACTIVITIES.

Support activities at MAF consist of engineering liaison with NASA and stage contractors in support of Saturn engines and support equipment.

3.2.3 MSFC SUPPORT ACTIVITY.

Support activity at MSFC consists of engineering liaison with NASA and stage contractors in support of Saturn engines and support equipment.

3.3 KSC AND MAF FIELD SITE OPERATIONS SUPPORT.

Field Site Operations support services at KSC consist of engine associated support to stage contractors for stage/engine operation events during stage flow from storage, stage refurbishment and checkout, through prelaunch and launch. Field Site Operations support services at MAF consists of engine associated support during stage storage. Stages removed from storage require personnel from KSC to prepare stage for shipment to KSC. Technical support is also provided during the F-1 and H-1 engine Storage Evaluation and Flight Worthiness Assessment period (Refer to section VIII, paragraph 8.3.2.) At KSC, in addition to the support tasks outlined in paragraph 3.2.1, Field Site Operations support is provided for SII and SIVB storage, prelaunch operations planning, Flight Readiness Review, and launch countdown and launch operations.

3.4 ENGINE INTERFACE.

Rocketdyne Field Site Operations personnel help stage contractors make engine connections and disconnections to the engine side of the stage interface (table 3-4). This includes installing and removing test plates and plugs for engine system leak and functional testing. All engine interface work that requires Rocketdyne's assistance is coordinated between Rocketdyne and the stage contractor and included in the Rocketdyne work documentation (FORR). Close coordination is maintained with the stage contractor to determine that all engine interface tasks are completed. Nonroutine engine interface problems are reviewed and resolved among Rocketdyne, stage contractor, and NASA.

Figure 3-3 and 3-4 deleted.

Rocketdyne Field Quality Assurance helps the stage contractor perform and document all inspection requirements associated with the engine interface work. A copy of Rocketdyne work and inspection buy-off documentation will be forwarded to the stage contractor for his records, if requested.

3.5 PERSONNEL SAFETY.

Rocketdyne Field Site Operations personnel assigned to NASA/stage contractor facilities comply with NASA, stage contractor, and Rocketdyne safety standards and procedures at each field site. The Rocketdyne Field Manager and/or Responsible Representative is responsible for making sure Rocketdyne Field Site Operations personnel adhere to all safety standards.

Rocketdyne technical manuals used at field sites in support of Saturn engines and related GSE, outline safety precautions for hazardous engine and GSE tasks.

Particular emphasis is also placed on complying with safety standards that govern, but are not limited to, the use, handling, and storage of the following:

a. Solvents.
b. Acids, caustics, and various other chemicals.
c. High-pressure gas systems.
d. Pyrotechnics and other explosives.
e. Electrical and electronic equipment.
f. Industrial equipment (hoisting and handling devices, welding, vehicles, etc).
g. Propellants.

At each field site the Field Manager or Responsible Representative, designates a Representative to participate in safety reviews and meetings with NASA/stage contractor personnel, to help improve and enforce safety standards and safe working conditions. All deviations to existing safety standards or requirements applicable to the use and handling of Rocketdyne-delivered engines and GSE are coordinated and approved through the Rocketdyne Industrial Hygiene and Safety Office, Canoga Park.

Table 3-4. Rocketdyne KSC Field Operations and Stage Contractor Integrated Responsibility

Task	Rocketdyne	Stage Contractor
Remove stage from storage.	-	X
Perform post-storage inspection of stage/engines.	X	X
Provide engine requirements for procedures.	X	-
Remove and replace engine.	X	-
Perform engine modifications.	X	-
Prepare stage/vehicle checkout procedures	-	X
Approve stage/vehicle checkout procedures.	X	X
Install and remove test plates, plugs, and covers internal to the engine system.	X	-
Perform engine systems and component leak checks.	X	X
Perform stage/engine functional and sequence tests.	-	X
Inspect maintenance tasks performed by Rocketdyne field operations personnel.	X	-
Inspect for stage/engine corrosion.	X	X
Inspect boattail before launch.	X	X
Perform vehicle launch countdown and launch.	-	X
Review post-launch data.	X	X
Proof-load, calibrate, and service engine GSE.	X	X
Perform engine component preinstallation testing.	X	-
Periodically test engine components.	X	-
Operate GFP engine and GSE support hardware center.	X	-
Maintain engine, component, and GSE configuration control.	X	X
Provide engine and GSE quality engineering guidance.	X	-
Provide disposition of engine/GSE hardware problems.	X	X
Provide engine orientation to stage contractor.	X	-
Maintain Engine Log Books and associated records.	X	X

SECTION IV
MAINTENANCE

4.1 GENERAL

This section outlines the various activities associated with maintenance of Saturn engines, components, and GSE. The maintenance activities outlined are the baseline for maintenance tasks and functions during the various phases of engine and GSE operation. Levels of maintenance are described and capabilities for performing maintenance are identified, to make sure that engines, spare components, and GSE retain their quality and reliability. References are made to technical manuals for definitive maintenance requirements and to appendix A for authorized engine repair at KSC.

4.2 ENGINE MAINTENANCE

During the field site operations flow of Saturn engines, activities are performed to fulfill engine maintenance and servicing support requirements. These activities are classified as scheduled, nonscheduled, and repair (figure 4-1).

Scheduled activities for uninstalled and installed engines support routine events in engine/stage/vehicle operations such as those identified in section III, Field Site Operations. The activities include inspection, electrical testing, leak and functional testing, storage, servicing, and handling. Scheduled engine activities and their associated requirements, limits, and constraints are identified in the following engine technical manuals.

a. R-3896-11, F-1 Rocket Engine Operating Instructions
b. R-3620-11, H-1 Rocket Engine Operating Instructions
c. R-3825-1B, J-2 Rocket Engine Operating Instructions

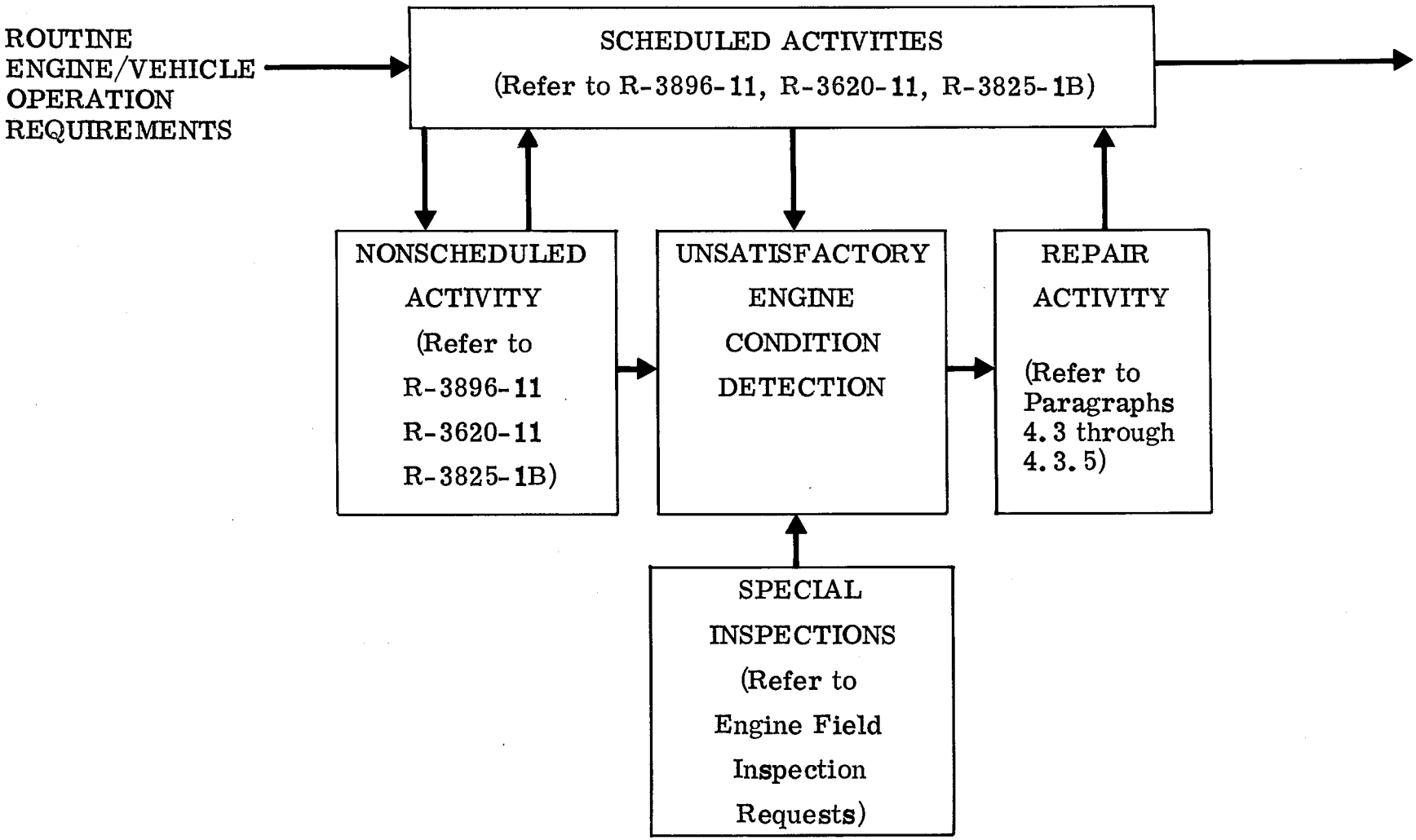

Figure 4-1. Engine Maintenance Activities

Nonscheduled activities are performed when nonscheduled events occur during the routine flow of an engine, stage, or vehicle. Events that require nonscheduled activity occur at random and include removing engines from storage, shipping uninstalled engines, recycling the launch countdown, and rescheduling the launch countdown. The nonscheduled engine activities include inspection, electrical testing, leak and functional testing, uninstalled engine shipment preparation, servicing, and handling. To quickly return the engine, stage, or vehicle to its operations flow when a nonscheduled event occurs, nonscheduled activities have been preplanned. Their limits, constraints, and procedures are included in the manuals listed above.

Repair is begun when scheduled or nonscheduled activities reveal an unsatisfactory engine condition. Following initial failure analysis and fault isolation, a course of corrective action is determined and authorizing documentation is prepared. Repair may also be initiated as a result of an EFIR inspection that is made when an unsatisfactory condition is suspected. The repair requirements and authority for this repair are in the EFIR. Depending on the position of the engine in the operations flow and the corrective action selected, repairs are made at KSC on the vehicle or off the vehicle. Figure 4-2 identifies the repair activities for each maintenance level. Paragraphs 4.3 through 4.5 describe the repair activities and serve as a guide for planning.

4.3 ENGINE FIELD SITE REPAIR

Engine field site repair consists of activities that can be done within the personnel, equipment, and facility capabilities, without affecting engine calibration and alinement and without degradation of support hardware.

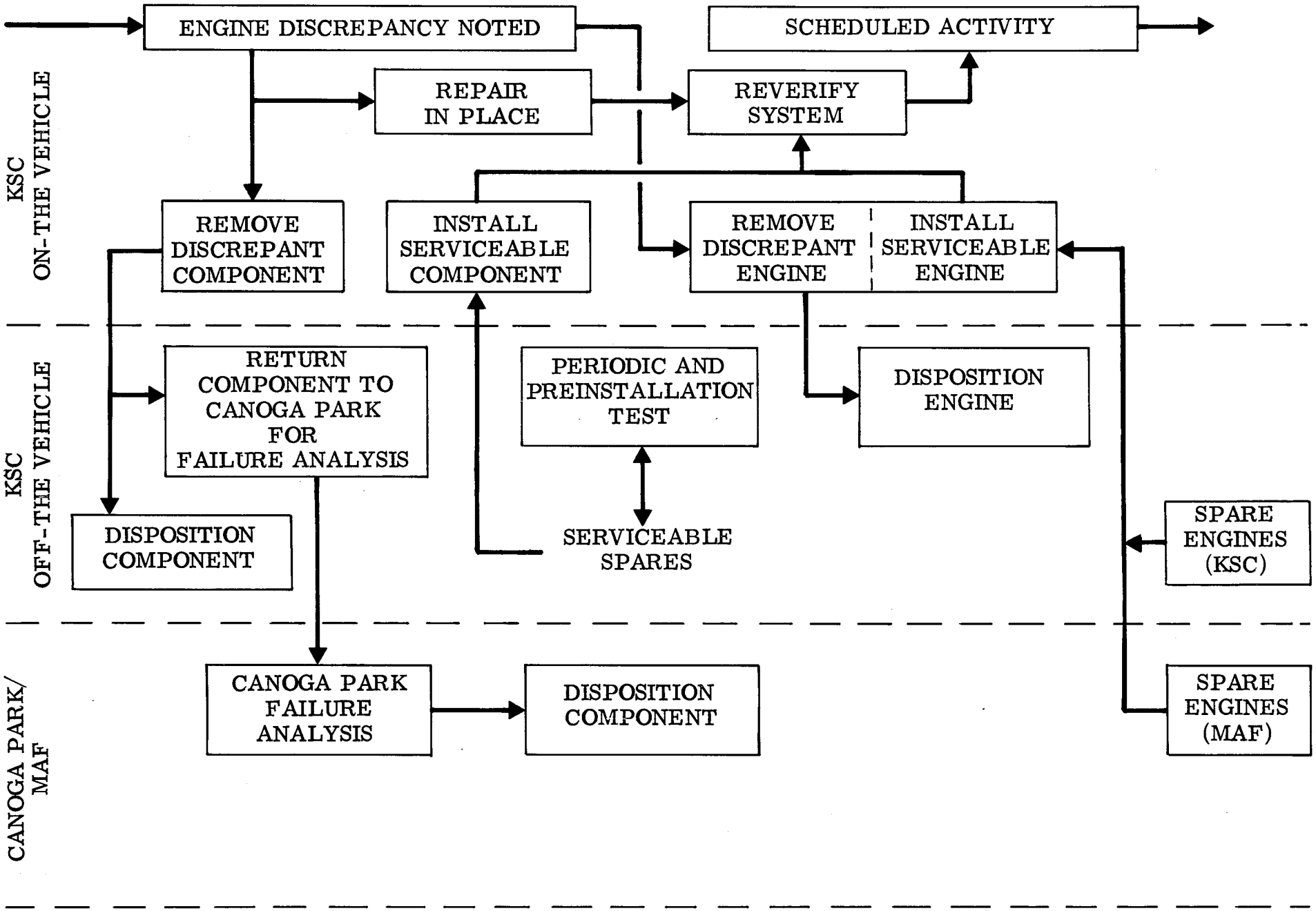

Figure 4-2. Engine Repair Activities

All field maintenance activities are performed and controlled by NASA/ Rocketdyne approved maintenance procedures in the following engine technical manuals, and in EFIRS:

a. R-3896-3, F-1 Rocket Engine Maintenance and Repair
b. R-3896-6, F-1 Thermal Insulation Installation and Repair
c. R-3620-3, H-1 Rocket Engine Maintenance and Repair
d. R-3825-3, J-2 Rocket Engine Maintenance and Repair

Field maintenance requirements vary with hardware design and reliability factors. Support equipment, documentation, facilities, and spare hardware requirements are continuously reviewed and analyzed to determine field maintenance support capabilities and requirements.

KSC is the only field location authorized to remove and replace or repair engine hardware. The authorized level of repair is presented in appendix A. Although some repairs can be made in place, engine repair is primarily removing and replacing or removing and reinstalling components or parts. Certain components and parts are "matched" during engine acceptance firing tests, and their replacement could adversely affect engine performance. Restrictions are imposed upon replacing these items without performing another acceptance firing test. The affects of component replacement are in the engine operating instructions manual.

4.3.1 SPECIALIZED ENGINE REPAIR

Specialized engine repair consists of repair at field sites where services of personnel with certain skills are not normally available. These personnel, equipped with approved procedures, tooling, and/or equipment are sent from Canoga Park to the field sites as required to perform the repair.

In addition to supporting the field sites, specialized personnel are also used to repair GFP engines and hardware returned to Canoga Park for factory repair, modification, and/or overhaul.

4.3.2 LAUNCH-CRITICAL ENGINE REPAIR

Engine repair after the vehicle is moved to the launch site can impact the launch schedule. Engine repair tasks that become necessary during the performance of scheduled launch countdown activities are considered launch-critical. Launch-critical spares are in table 4-1. Launch-critical spares are stocked at the KSC warehouse except for ordnance which is stored by the service contractor.

To be identified as a launch-critical spare, an item must meet the following criteria: (1) its satisfactory operation is mandatory for launch/mission; (2) it can be replaced on-the-vehicle by site personnel using equipment available at the site; and (3) once the launch countdown has started, the failed part can be identified, replaced, and verified in the system within 12 hours.

Table 4-1. Launch Critical Spares

Spare Component	Engine
Mainstage/Thrust OK Pressure Switch	F-1, H-1, J-2
Hypergol Cartridge	F-1
Gas Generator Igniter	F-1
Turbine Exhaust Igniter	F-1
Hypergol Igniter Monitor Switch	H-1

4.3.3 ENGINE REVERIFICATION TESTING

Engine systems that are violated for scheduled or nonscheduled maintenance operations, including EFIRs and modifications, are tested to verify the engine systems integrity. To prevent redundant testing, engine systems that are violated during repair or modification activities are reverified during scheduled test activities. If reverification requirements are outside the scope of scheduled testing, or if delay in testing will delay vehicle schedule, reverification tests are part of the nonscheduled repair activities. Requirements for reverification tests following modification are in the modification instructions. Requirements for reverification testing following repair are in the engine maintenance and repair manuals R-3896-3, R-3620-3, and R-3825-3. Instructions to be used after repair or modification are in the engine operating instructions manuals R-3896-11, R-3620-11, and R-3825-1B. Stage contractor procedures are used for scheduled test activities.

4.3.4 ENGINE MAINTENANCE RECORD

All maintenance activities on the Saturn engines after delivery to NASA are initiated and controlled by approved Rocketdyne and NASA documentation (section VI, Support Documentation). Various documentation, including the Rocketdyne FORR, is used to record and provide a history of all maintenance on the engines, during the factory-to-launch operations phase. However, the official NASA record of all engine maintenance that affects the engine's structure, operation, or configuration is the Engine Log Book. The log book is delivered with each engine and is maintained through vehicle launch operations.

4.3.5 ENGINE CONFIGURATION CONTROL

A configuration status accounting system is used to report engine hardware configuration. Configuration Identification & Status Reports R-5857 (F-1), R-7392 (H-1), and R-5788 (J-2) are updated as required. These reports identify and describe the approved ECP configuration, effectivity, kit delivery schedule, and supporting data. A compilation of data extracted from FORRs, approved ECPs, and other Rocketdyne, stage contractor and NASA data, is used to prepare the reports.

4.4 COMPONENT MAINTENANCE

Engine field site repair is limited to KSC and is supported by component repair activities at KSC and Canoga Park and by hardware spares stocked at KSC. Paragraphs 4.4.2 through 4.4.5 describe component repair and maintenance activities.

4.4.1 (Deleted)

4.4.2 COMPONENT REPAIR - KSC

Limited in-place engine component repair or replacement is performed at KSC. The repair capability authorized at KSC is noted, by component, in appendix A. This capability is augmented, as necessary, by specialized personnel and equipment. The limits, requirements, and procedures for component repair as specified in appendix A are in the engine maintenance and repair manuals R-3896-3, R-3620-3, and R-3825-3. Components that require major disassembly are dispositioned at KSC or are returned to Canoga Park for disposition.

4.4.3 through 4.4.4 (Deleted)

4.4.5 COMPONENT TESTING

Capability for limited engine component testing is provided at KSC. Component test requirements and procedures are in the engine maintenance and repair manuals R-3896-3, R-3620-3, and R-3825-3. Components requiring calibration and analytical testing beyond the capability of the KSC test equipment are returned to Canoga Park. T-tooling required to test the components is stored at KSC and is returned to Canoga Park with the component requiring retest.

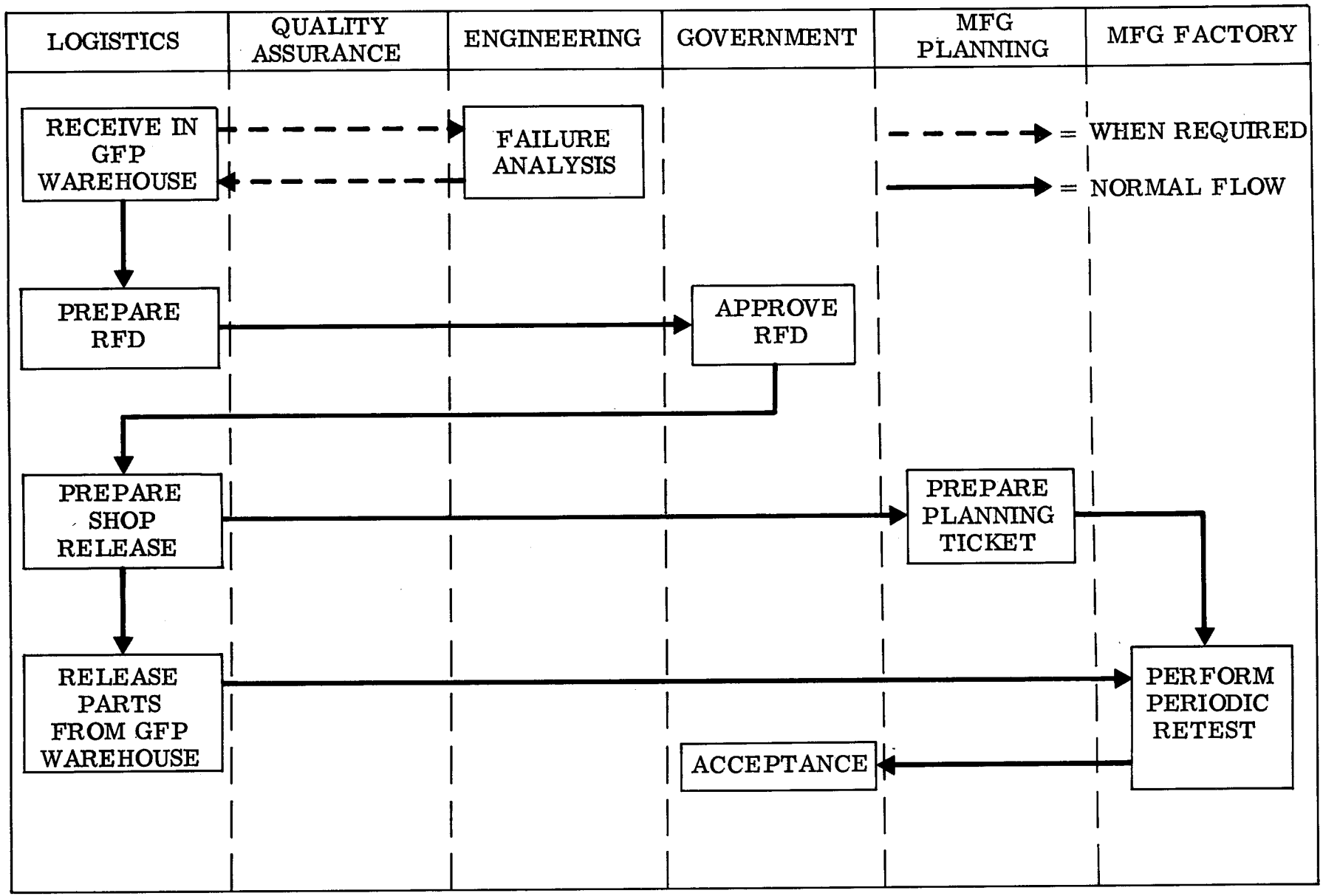

Figure 4-3. Canoga Park Component Flow

4.4.5.1 PERIODIC RETEST OF ENGINE COMPONENT SPARES

Periodic retest requirements have been established for spare components that are subject to time-oriented failure modes or have significant failure modes. These components (listed in the engine technical manuals) must be functionally retested within a specified time-period (six months or 12 months) before installation. They are retested in accordance with instructions in the engine maintenance and repair manuals. Retest of certain components requires capabilities available at Canoga Park.

4.4.5.2 PREINSTALLATION RETEST OF ENGINE COMPONENT SPARES

Preinstallation retesting is required for some spare components to ensure a failure does not exist that could have developed since a fixed interval checkout was performed. These components (listed in the engine technical manuals) must be retested before installation. The testing capability is available at KSC and Canoga Park.

4.5 HANDLING AND DISPOSITIONING FAILED HARDWARE

In accordance with the maintenance concept, Rocketdyne and NASA have established a system for handling and dispositioning failed GFP hardware. The system provides the authority and documentation that enables Rocketdyne personnel to analyze and handle failed GFP hardware.

4.5.1 UCR REPORTING

UCRs are initiated within 24 hours when: (1) an engine component malfunctions or does not perform according to the pertinent Rocketdyne operational specification during hot fire or after once having demonstrated satisfactory performance as a component; (2) a condition causes premature cutoff or a hazard to equipment or personnel; (3) a component is removed from an

engine because of a suspected malfunction; (4) is required by Rocketdyne specification or other engineering documentation; (5) a human error occurs or an authorized Rocketdyne procedure is in error, ambiguous, or contains an omission, either of which would permit any of the above conditions to develop.

When available, the stage contractor failure report is entered on the UCR. A copy of the UCR is given to NASA at the field site.

UCRs are not written to report:

a. That an operation was performed and no unsatisfactory condition was noted.

b. Obvious misuse, mishandling, superseded configuration, or degradation beyond specified life requirements.

c. That a part was replaced or modified in accordance with a Modification Instruction or EFIR and no discrepancies were noted.

d. Replacement or repair of a part specifically required to be serviced as scheduled maintenance in accordance with official Logistics procedures, and which exhibits no unusual defects.

e. A condition where the component performs to the Rocketdyne specification but does not satisfy a requirement of a non-Rocketdyne specification.

f. Cosmetic deficiencies.

g. Instrumentation malfunctions that do not affect engine operation.

h. Minor malfunctions in ground support equipment or T-tool except where the malfunction results in a hazard to personnel or engine.

4.5.2 FIELD SITE COMPONENT FAILURES

When an engine component fails, it is removed (per NASA approval) by Field Site Operations personnel and returned to the GFP Warehouse, and a replacement part is issued. A UCR is prepared listing a brief description of the cause of failure and the apparent damage. When a component requires repair or failure analysis, a recommendation for

hardware disposition is prepared on the back side of the hard copy of the UCR recommending the component be held for local repair or returned to Canoga Park for further disposition. The resident NASA Engine Project Office Representative or his representative at the field site reviews the Rocketdyne recommendation, determines the course of action, and signs the UCR, authorizing Field Site Operations personnel to proceed with the disposition of the component. When a component is to be returned to Rocketdyne, the UCR hard copy is attached to the component. If NASA or stage contractor procedures require that the hard copy of their discrepancy report be attached (to clear the Material Review Board and GFP Stores), both hard copies are attached to the component. Field Site Operations personnel are responsible for ensuring that the UCR hard copy and the Failure Analysis Rush Tag (if required) are attached to the component before it is returned to Canoga Park. (Conditions defined as "Critical and Major Failures" require that a Failure Analysis Rush Tag be attached to the part before it is returned to Canoga Park.) Copies of the UCR are forwarded to the resident NASA Engine Project Offices at the field site.

4.5.3 FIELD CORRECTIONS

When UCRs are written against hardware unsatisfactory conditions and the discrepant hardware is corrected at the field site, Rocketdyne Field Site Operations personnel prepare a Failure Analysis Report and forward copies to appropriate Rocketdyne offices.

4.5.4 FAILURE ANALYSIS

GFP hardware returned to Canoga Park by UCR action is assigned by Reliability Projects for analysis. A failure analysis plan of action is prepared for each failure analysis. All critical and major failures are assigned for analysis, however, a complete analysis may not be required when the failure mode is known through examination of previously failed hardware. Minor failures are not assigned for analysis unless the failed condition is new, unusual, etc, or an analysis is requested by NASA.

After failure analysis, the hardware and the hard copy of the UCR are returned to the GFP warehouse for further action, along with a record of the environment (testing performed, degree of disassembly, etc) the hardware has been subjected to in failure analysis and a statement regarding the suitability of the hardware for refurbishment, as a flight spare.

4.5.5 through 4.5.6 (Deleted)

4.6 GSE MAINTENANCE

Delivered GSE in the custody of Rocketdyne requires various levels of maintenance at periodic intervals. Also, certain special test equipment used for engine and GSE maintenance requires periodic maintenance, calibration, and servicing. Procedures in the engine technical manuals are followed to fulfill these requirements. Rocketdyne field site operations personnel do all maintenance tasks except calibration, proof testing, and proof loading. The stage/support contractor at the field site calibrates GSE in the custody of Rocketdyne.

Field Site Operations personnel provide maintenance services on an as-required basis in support of delivered GSE in the custody of the stage contractors. These services assist the stage contractor in maintaining GSE in a serviceable condition and to the latest approved configuration.

4.6.1 GSE FIELD REPAIR

GSE is repaired at the field site by replacing discrepant part, components, or subassemblies. The field repair level of GSE is outlined in the following technical manuals:

a. R-3896-5, F-1 Rocket Engine Ground Support Equipment Maintenance and Operation

b. R-3620-3, H-1 Rocket Engine Maintenance and Repair

c. R-3825-5, J-2 Rocket Engine Ground Support Equipment Maintenance and Repair

4.6.2 GSE REPAIR - CANOGA PARK

GSE requiring repair that exceeds the repair capability at the field sites may be dispositioned for return to Canoga Park. An analysis of the GSE failure mode is made by Engineering, to determine if a design change is required. A record of repair is retained in the Logistics Stock Record files and the Quality Assurance IDR retention records.

4.6.3 CALIBRATION OF GSE

Delivered GSE is calibrated on a periodic basis as outlined in the engine technical manuals and Field Quality Assurance Manual.

4.6.4 GSE AND SUPPORT EQUIPMENT CLEANNESS

GSE and Support Equipment used for engine and component checkout, purging, or flushing is certified clean before use. No item of GSE or support equipment is connected to or used in an engine system or component unless the cleanness of the item meets the intent of the cleanness requirements specified in the MSFC-STD-146. All GSE and support equipment requiring cleaning (hoses, lines, plugs, plates, etc) is cleaned in accordance with the engine technical manuals.

4.6.5 GSE CONFIGURATION CONTROL

To maintain configuration traceability on GSE modifications and EFIRs, a FORR is prepared for each approved modification or EFIR to be performed on items of GSE requiring configuration control. The FORR contains item and part number and approved ECP/EFIR data necessary to record the information in the Configuration Identification & Status Reports.

4.6.6 GSE RECORDS

A record of GSE configuration, calibration, and servicing operations is maintained for all engine GSE by Field Operations personnel.

4.7 SPECIAL TOOLS AND TEST EQUIPMENT

Special tools and test equipment (STE) are provided by Rocketdyne to perform component repair, engine checkout, and engine servicing. This equipment is calibrated and serviced on a periodic basis in accordance with Rocketdyne procedures and quality assurance standards.

Configuration control for all special tools and test equipment at field sites will be maintained. The modification of special tools and test equipment at field sites will be accomplished through the FORR system and in accordance with the released tool order and drawing. When special tools or test equipment are returned to Canoga Park for modification, the Spares personnel will process the tool and/or test equipment through the hardware servicing system and make sure the hardware is modified and returned to the field site.

4.8 HANDLING GOVERNMENT PROPERTY - EFL WAREHOUSE

Government property consisting of provisioned spares, tooling, STE, GSE, and related program inventory items are received and stored at the EFL warehouse.

Engine hardware excess to current program needs is segregated and stored at EFL as residual hardware. If it is determined by NASA that this hardware will be used for production or flight support, the hardware will be inspected at Canoga Park to ensure that all drawings requirements are met. This inspection consists of reviewing the accompanying planning tickets, LOX cleanness integrity, time since last functional test (if applicable) and all other pertinent requirements specified by the drawing. Hardware that cannot be verified is tested and subsequently repaired under the Hardware Servicing Clause of the Contract.

Tooling, STE, GSE, and related program inventory items stored at EFL are handled as termination inventory hardware. The removal and processing of termination inventory hardware for use in support of the current program is handled in accordance with direction of the NASA MSFC Contracting Officer.

SECTION V

SUPPORT EQUIPMENT

5.1 GENERAL.

This section specifies the support equipment retained to support the Saturn resources program and the Apollo Soyuz Test Project. (Refer to appendix C.) Support equipment for F-1 engines (appendix C, table C-1) is located at sites designated in R-5857. Support equipment for H-1 engines (appendix C, table C-2) is located at sites designated in R-7392. Support equipment for J-2 engines (appendix C, table C-3) is located at sites designated in R-5788.

SECTION VI

SUPPORT DOCUMENTATION

6.1 GENERAL.

This section identifies the support documentation used to define, manage, and perform Rocketdyne support of Saturn engines and related support equipment. Figure 6-1 lists the documentation by functional category and illustrates the relationship among categories. The documentation provides a support system with continuity and the capability of disseminating vital program information in a timely and controlled manner.

Table 6-1 briefly describes each document and identifies program application, contractual obligation, and approval, distribution, and revision/update requirements.

6.2 ENGINE PROGRAM CONTRACT.

The engine program contract specifies the services and supplies to be provided by Rocketdyne to support Saturn engines and associated GSE. The Data Requirements List (DRL) and Data Requirement (DR) in the contract specify what items of support documentation are required and briefly describe the minimum contents of the data. In addition, the DR lists the update, printing, and NASA approval requirements.

6.3 ROCKETDYNE AND LOGISTICS INTERNAL POLICIES.

Internal policies provide the guidelines for effectively managing Rocketdyne operations in the home office and the field. The policies document methods and procedures that provide consistent and effective operations.

6.4 REQUIREMENTS AND PROCEDURES.

All field maintenance performed on Rocketdyne delivered engines and GSE is done in accordance with Rocketdyne approved requirements and procedures. The requirements and procedures are in technical manuals or special instructions.

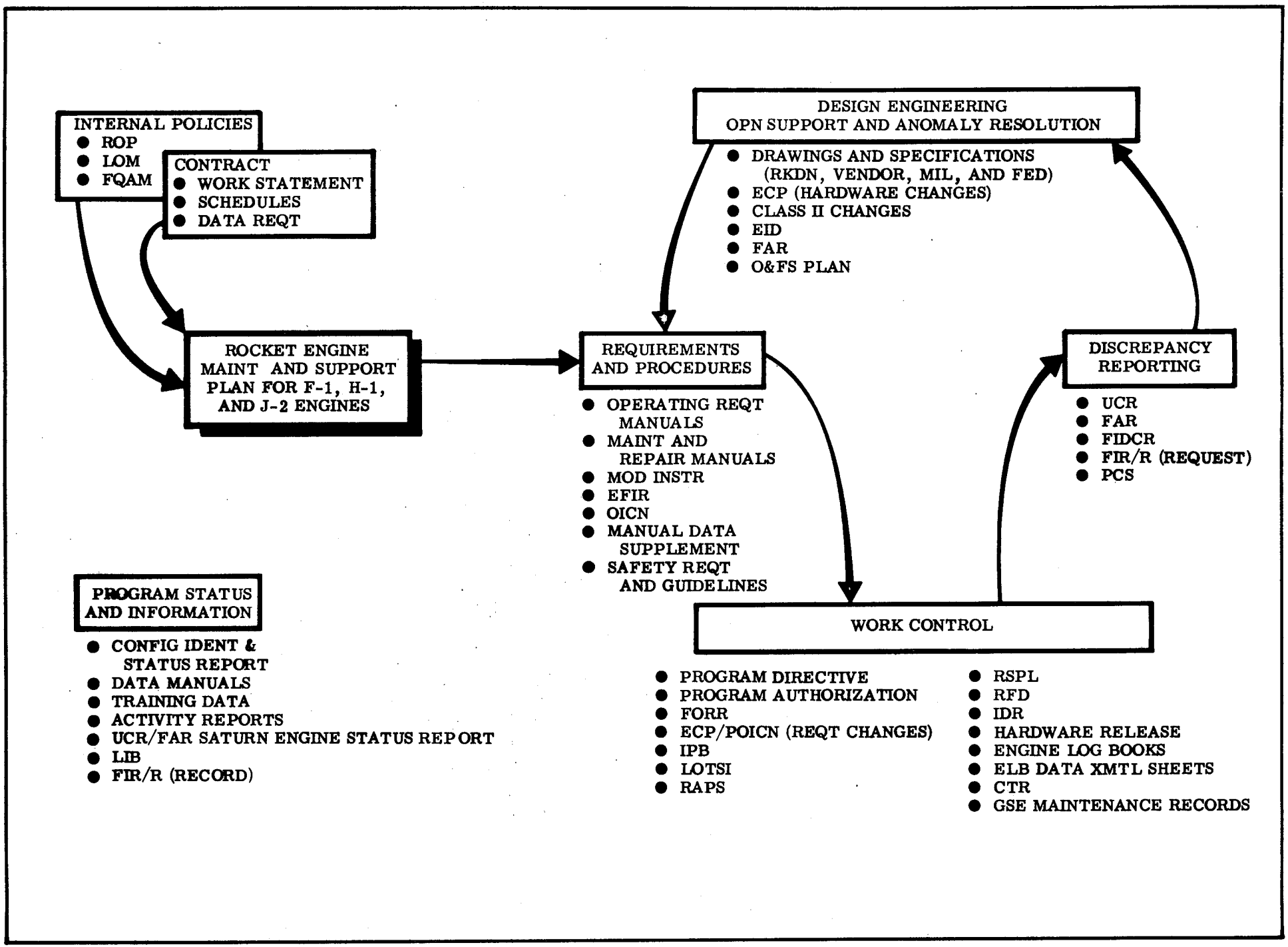

Figure 6-1. Support Documentation

6.4.1 TECHNICAL MANUALS.

Engine operating requirements are in sections I and II of the Operating Instructions Manuals for each engine system. These manuals represent Rocketdyne's official operating requirements for delivered engines. All changes to engine operating requirements are coordinated and controlled due to the impact they may have on stage contractor operations and flight vehicle mission success. Changes are issued on Operating Instruction Change Notices (OICNs) for H-1 and F-1 engines. These OICNs are processed through the ECP system and receive total coordination and signature approvals from Rocketdyne and NASA.

Maintenance tasks performed by Field Site Operations personnel (eg, cleaning, servicing, repair, test, etc) are supported by detailed procedures in maintenance and repair manuals. The manuals provide repair procedures which exceed the level of repair authorized in appendix A. Use of those procedures requires program authorization.

Engine checkout procedures present Rocketdyne's recommended method for performing the checkout necessary to satisfy operating requirements. This procedural data is available to the stage contractors to develop their engine-oriented stage procedures.

Normal updating of procedural data to meet changing program needs is done by accumulating affected data into scheduled manual changes. Manual Data Supplements or non-ECP-controlled OICNs are issued for urgent data changes. Supplements and OICNs are incorporated into the manuals during subsequent manual changes.

6.4.2 SPECIAL INSTRUCTIONS.

Special instructions (Modification Instructions and Engine Field Inspection Requests) are issued to present the technical requirements to be followed when performing special tasks of a nonroutine, nonrepetitive nature. These documents have a specific engine, GSE, part, or component effectivity. After the instructions are complied with on all the affected items, the instructions become inactive and require revision to reinstate.

6.5 WORK CONTROL DOCUMENTATION.

Work control documentation authorizes and records task accomplishment, monitors and controls the Spares Management program, and provides official individual field records of engines, components, and GSE status. Documentation that is peculiar to the day-to-day internal operations of individual functional units has not been listed.

At KSC, in addition to the Rocketdyne work control documentation, Joint Operating Agreements between Rocketdyne and the S-II and S-IVB stage contractors are prepared to provide technical instructions, controls, and guidelines for Rocketdyne field site operations.

6.5.1 TASK AUTHORIZATION AND TRACEABILITY.

Task authorization documentation provides the authority to start and complete a task. These documents consist of Program Directives and Program Authorizations (Rocketdyne internal documents that provide program authority) and the FORR (a field document that indicates NASA's approval for Rocketdyne to proceed with a specific task).

The FORR is the most important item of support documentation in the daily routine of field operations. The FORR authorizes, documents, and records task completion for every maintenance task Rocketdyne personnel perform on engines, components, and GSE in the field. Details for the use of the FORR are in the Logistics Operating Manual (LOM), however, a brief description of the FORR system has been included in this plan to describe its primary use.

When a task is to be performed by Rocketdyne personnel, the FORR system is implemented by Field Operations as follows: (See figure 6-2.)

a. The task requirements document (Modification Instruction, EFIR, UCR, etc) is obtained. All documents referenced by the task requirements document are also obtained. The FORR Form 612-D-15 or subsequent stage contractor documentation is then presented to NASA for "go-ahead" approval signature.

b. After approval, the task is performed by Rocketdyne personnel in accordance with the quality assurance requirements in the task requirements document. A Field Inspection Discrepancy and Correction Record (FIDCR) in the FORR work package is used to record discrepancies, deviations, or deficiencies noted during performance of the task.

c. As the task progresses, the required Rocketdyne and NASA signatures are obtained. If the task cannot be completed at this time, eg, additional testing is required at a later date or different location, only the completed portion of the FORR is signed and the FORR is placed in a suspense file.

d. When the task is completed, the Certificate of Completion signatures are obtained and the FORR work package distributed and filed in accordance with the LOM.

e. The completed FORR work package provides records for traceability of all tasks performed by Rocketdyne on engines, components, and GSE.

6.5.2 CHANGES TO ENGINE OPERATING REQUIREMENTS.

All changes to the engine operating requirements in the F-1 and H-1 Operation Instructions manuals are initiated and approved through the ECP/POICN system. Changes to J-2 engine operating requirements are approved by Rocketdyne Saturn Program Configuration Control Board (PCCB). The PCCB either reviews and approves changes to the basic source document

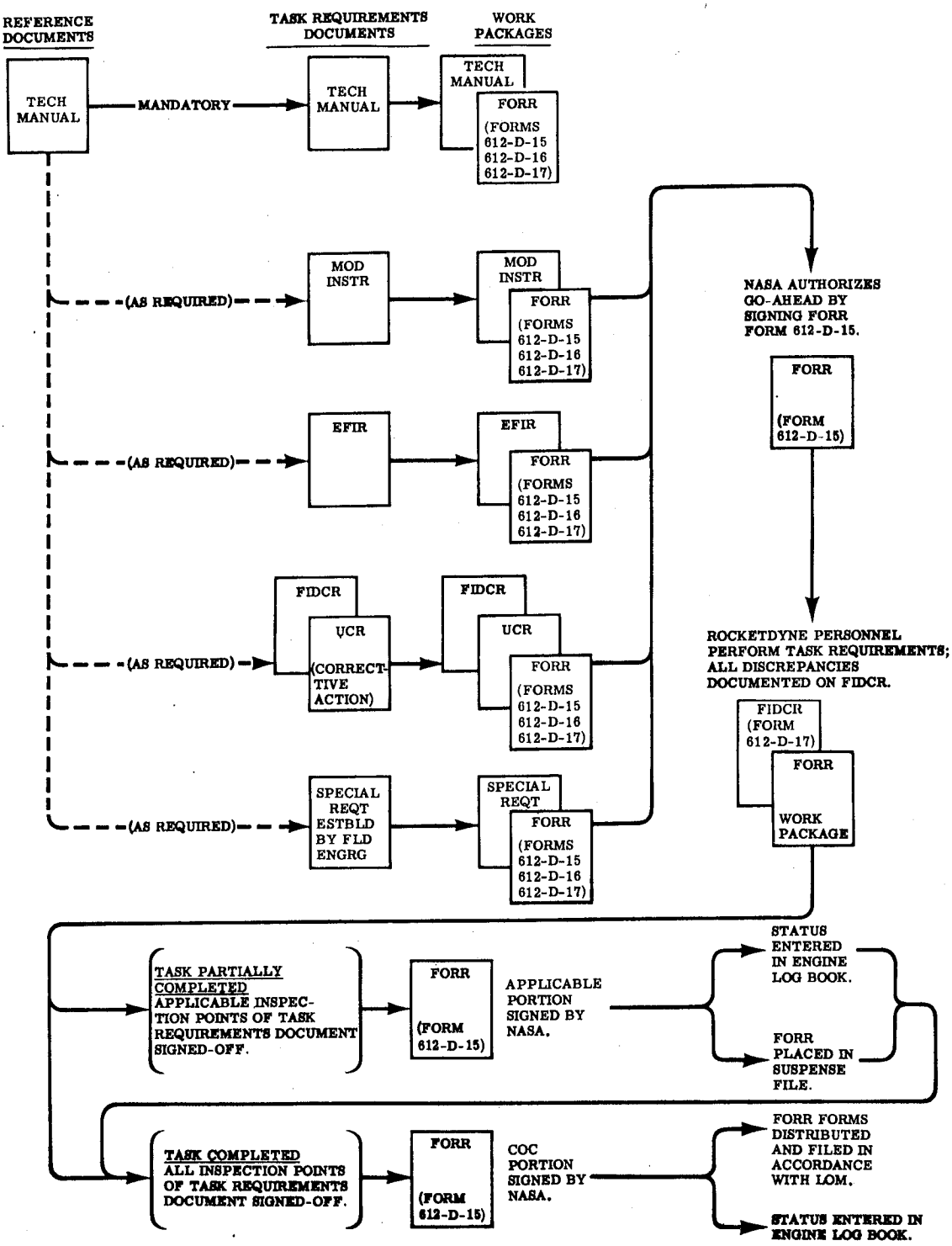

Figure 6-2. FORR System

(drawings, specifications, etc) or reviews the individual manual changes directly. In addition, changes to J-2 engine operating requirements that may cause stage impact are informally presented to the stage contractor representative for consideration.

6.5.3 SPARES.

Spares documentation includes the reports, manuals, and forms used to procure, ship, disposition, and monitor spares. The documentation provides a formal system for conveying spares information between NASA and the Rocketdyne home office and field sites, and includes IPBs, the LOTSI report, RAPS, RSPLs, RFDs, and Logistics Hardware Releases.

6.5.4 ENGINE AND GSE HISTORICAL RECORDS.

Engine Log Books and data transmittal sheets, component test records (CTR), and GSE maintenance records provide authoritive documents for recording significant events, past performance values, operational life data, and servicing/maintenance status of engines, components, and GSE.

6.6 DISCREPANCY REPORTING.

Documentation used to report discrepancies includes the UCR, FAR, FIDCR, PCS and FIR (Request). These documents describe suspected or identifiable problems and are used to support the action necessary to resolve the problem and make adjustments to prevent recurrence of the problem.

6.7 ENGINEERING DOCUMENTATION.

Engineering documentation is the primary source data for developing requirements and procedures. It provides design features, operating criteria, and a system for developing and controlling design changes. Engineering documentation is thoroughly analyzed and adapted to field application during the development of support documentation and continuously monitored for changes that require revision/change to the support documentation. Figure 6-3 shows an example of how the approval and issuance of a hardware ECP can impact the support documentation system.

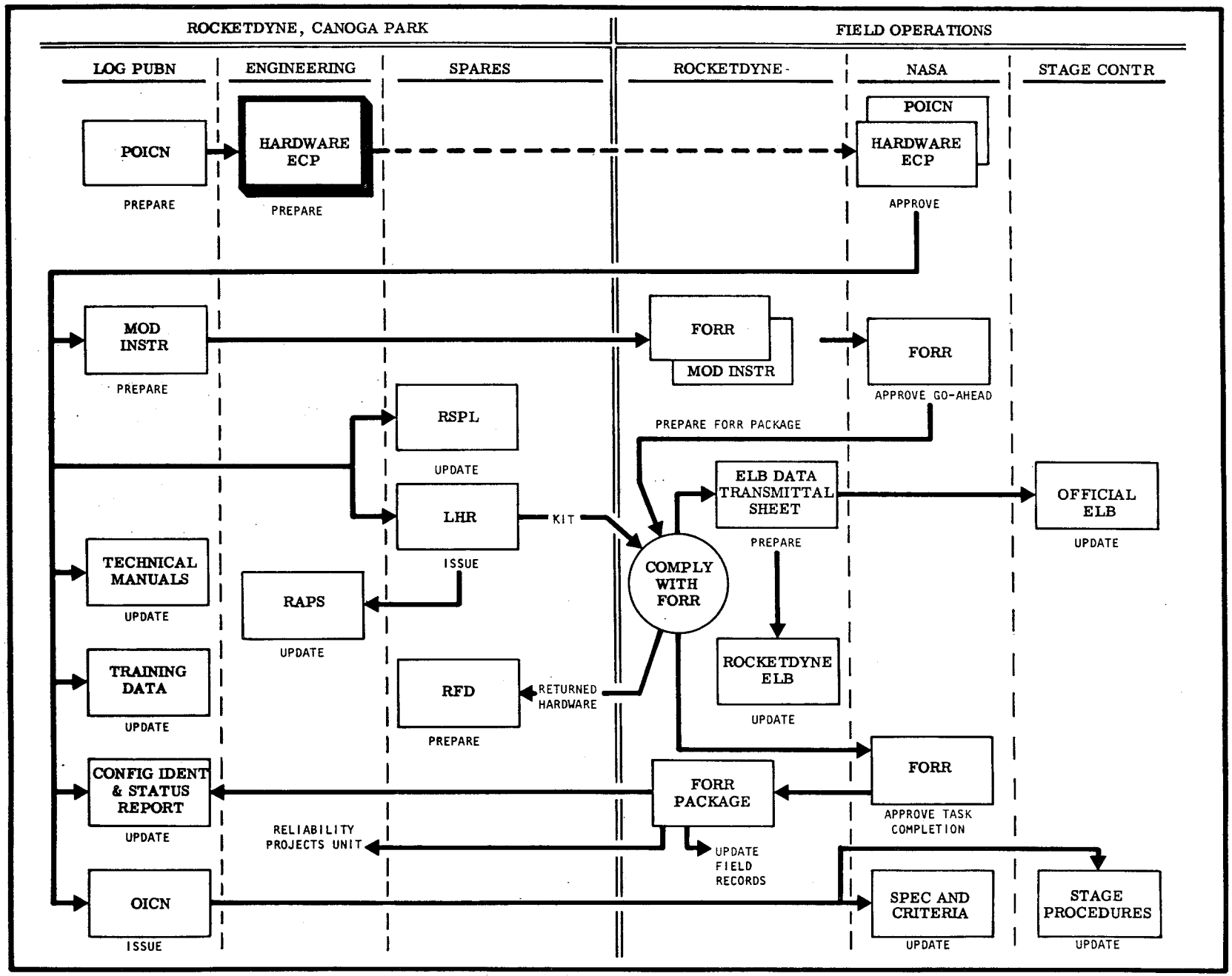

Figure 6-3. Support Documentation Response to Hardware Changes

6.8 PROGRAM STATUS AND INFORMATION.

Information describing the engine and the program is provided through formal (contractual) and informal status reports and general program information documents.

6.8.1 FORMAL STATUS REPORTS.

Formal (contractual) status reports provide the status of delivered engines, support hardware, and hardware discrepancies. These reports include the Configuration Identification & Status Report and UCR/FAR Saturn Engine Status Report. The data in the reports is monitored, revised, and distributed on a schedule dictated by contract.

6.8.2 INFORMAL STATUS REPORTS.

Rocketdyne Logistics internal policies dictate that a continual exchange of home office/site activity and program information be maintained to provide Rocketdyne and NASA with current overall program status. This is done by preparing, approving, and issuing home office and site activity reports.

6.8.3 GENERAL INFORMATION.

General information documentation provides a formal system for distributing data that describes engine design and operations characteristics and tentative program schedules. This documentation consists of the data manuals, training data, and Logistics Information Bulletins.

Table 6-1. Support Documentation Summary (Sheet 1 of 8)

Item No.	Purpose	Report/ Form No.	Program Application			Contract Reqt	NASA Approval		Formal Distribution			Update Frequency	
			H-1	F-1	J-2		Resident Representative	By ECP CCN	Rkdn	NASA	Stg Contr	As Reqd	Other
INTERNAL POLICIES													
1.	ROCKETDYNE OPERATING POLICIES AND PROCEDURES (ROP) Provide the administrative and operating policies and procedures applicable to Rocketdyne internal requirements.	(None)	X	X	X				X			X	
2.	LOGISTICS OPERATING MANUAL (LOM) Define the policies and procedures that govern Logistics personnel in day-to-day activities. Instructions are provided for guidance in the administration of personnel services at Canoga Park and field sites. Applicable Rocketdyne Operating Procedures are expanded to provide the needed degree of detail for Logistics use. The LOM must be used for specific instructions in such areas as hiring, transfer, and termination of field personnel; provisioning, shipping, handling, and storage of hardware; field site activation and deactivation; and field task documentation through the Field Operation Requirement and Record (FORR) system.	(None)	X	X	X				X			X	
3.	FIELD QUALITY ASSURANCE MANUAL (FQAM) Provide an authoritative document for defining the procedural requirements of the Field Operations Quality Program and implementing the basic elements of the Rocketdyne Quality Program Plan, R-6158-4.	578-D-5	X	X	X				X			X	
4.	QUALITY ASSURANCE INSTRUCTIONS (QAI) Supplement the FQAM with procedural instructions for specific requirements applicable to a particular assignment, engine program, etc.	(Corresponds to FQAM procedure number	X	X	X				X			X	
5.	FIELD QUALITY OPERATING INSTRUCTIONS (FQOI) Supplement the FQAM with the necessary detail Quality Assurance operations peculiar to each site, FQOIs are prepared, signed, and issued at the field sites.	(Corresponds to FQAM procedure number	X	X	X				X			X	
ROCKET ENGINE MAINTENANCE AND SUPPORT PLAN FOR F-1, H-1, AND J-2 ENGINES Define Rocketdyne's support functions and provide maintenance and support planning information.		R-8842	X	X	X	X	X		X	X	X	X	

Table 6-1. Support Documentation Summary (Sheet 2 of 8)

Item No.	Purpose	Report/ Form No.	Program Application			Contract Reqt	NASA Approval		Formal Distribution			Update Frequency	
			H-1	F-1	J-2		Resident Representative	By ECP CCN	Rkdn	NASA	Stg Cont	As Reqd	Other
REQUIREMENTS AND PROCEDURES													
1.	ROCKET ENGINE OPERATING INSTRUCTIONS MANUAL	R-3620-11	X			X	X (Sect III)	X (Sect I&II)	X	X	X	X	
	Provide Rocketdyne/NASA authorized field operating requirements for flight engines during a complete operational flow. Specific and general engine requirements, including acceptability criteria and limits, special constraints, and safety precautions are in sections I and II. Rocketdyne's recommended procedures for fulfilling the requirements are in section III.	R-3896-11		X		X	X (Sect III)	X (Sect I&II)	X	X	X	X	
		R-3825-1B			X	X	X (All Sect)		X	X	X	X	
2.	OPERATING INSTRUCTION CHANGE NOTICES (OICN)	(Numbered consecutively by program)	X	X		X		X	X	X	X	X	
	Provide a method for issuing urgent Rocketdyne/NASA authorized changes to operating requirements contained in the Operating Instructions Manuals for F-1 and H-1 programs.												
3.	ROCKET ENGINE MAINTENANCE AND REPAIR MANUAL	R-3620-3	X			X	X		X	X	X	X	
		R-3896-3		X		X	X		X	X	X	X	
	Provide Rocketdyne authorized maintenance and repair requirements and procedures applicable to the specific engine and its components. (For H-1, the manual also contains GSE maintenance and repair requirements and procedures.)	R-3825-3			X	X	X		X	X	X	X	
4.	GSE MAINTENANCE AND REPAIR/OPERATION MANUAL	R-3896-5		X		X	X		X	X	X	X	
		R-3825-5			X	X	X		X	X	X	X	
	Provide Rocketdyne authorized maintenance and repair requirements and procedures, and parts listings for Rocketdyne supplied GSE applicable to the specific engine program. (Requirements and procedures for H-1 GSE is in R-3620-3.)												
5.	F-1 ROCKET ENGINE THERMAL INSULATION INSTALLATION AND REPAIR	R-3896-6		X		X	X		X	X	X	X	
	Provide Rocketdyne authorized maintenance and repair requirements and procedures for F-1 engine thermal insulation. (Requirements and procedures for H-1 and J-2 thermal insulation are in R-3620-3 and R-3825-3, respectively.)												
6.	F-1 ROCKET ENGINE TRANSPORTATION MANUAL	R-3896-9		X					X	X	X	(By Log Mgr direction)	
	Provide Rocketdyne authorized requirements and procedures for preparation and shipment of F-1 engines, nozzle extensions, thermal insulation, and loose equipment. (Requirements and procedures for transporting H-1 and J-2 engines are in R-3620-3 and R-3825-3, respectively.)												
7.	STANDARD MAINTENANCE AND REPAIR MANUAL FOR LIQUID ROCKET ENGINES AND ASSOCIATED SUPPORT EQUIPMENT	R-8262	X	X	X				X			X	
	Provide a central source of Rocketdyne authorized general maintenance and repair information and fundamental reference material for liquid												

Table 6-1. Support Documentation Summary (Sheet 3 of 8)

Item No.	Purpose	Report / Form No.	Program Application H-1	Program Application F-1	Program Application J-2	Contract Reqt	NASA Approval: Resident Representative	NASA Approval: By ECP CCN	Formal Distribution: Rkdn	Formal Distribution: NASA	Formal Distribution: Stg Cont	Update Frequency: As Reqd	Update Frequency: Other
8.	MANUAL DATA SUPPLEMENTS Provide a rapid method for issuing urgent authorized changes or additions to technical manuals (except for Operating Instructions Manuals on the F-1 and H-1 programs.)	(Numbered consecutively by manual, ex: R-3620-3-1)	X	X	X	X	X		X	X	X	X	
9.	MODIFICATION INSTRUCTIONS Provide Rocketdyne authorized instructions for making ECP-approved changes to delivered hardware.	R-1591-(ECP No.)	X			X		X	X	X		X	
		R-5266-(ECP No.)		X		X		X	X	X		X	
		R-5436-(ECP No.)			X	X		X	X	X		X	
10.	ENGINE FIELD INSPECTION REQUESTS (EFIR) Provide Rocketdyne authorized instructions for performing nonroutine, nonrepetitive field inspections, or work of non-ECP nature on delivered hardware.	(Numbered consecutively by program, ex: H1-1)	X	X	X	X	X		X	X		X	
11.	SAFETY REQUIREMENTS AND GUIDELINES Provide guidance and direction necessary to conduct Rocketdyne field operations in a safe manner. Specific precautions and warnings relative to performing maintenance and operating procedures are appropriately located within the requirement/procedural documentation. General policies, responsibilities, and guidelines are in Rocketdyne, stage contractor, and NASA generated documentation, eg, Joint Operating Agreement, site operating directives, etc. Government documentation (Military, Federal, and Civil) is also referenced for specific safety requirements applicable to the aerospace industry in general.		X	X	X								
WORK CONTROL DOCUMENTATION													
1.	PROGRAM DIRECTIVE (PD) An internal document issued by Program Control to provide authority and direction to the Subdivision of Works Manager for completion of the work specified in the directive.	Form 605-Y-16/17	X	X	X							X	
2.	PROGRAM AUTHORIZATION (PA) An internal document issued by the Subdivision of Works Manager to provide authority and direction to the functional (doing) organization for completion of the work specified in the authorization.	Form 610-C-195 or Form 639-B	X	X	X							X	

Table 6-1. Support Documentation Summary (Sheet 4 of 8)

Item No.	Purpose	Report/ Form No.	Program Application			Contract Req't	NASA Approval		Formal Distribution			Update Frequency	
			H-1	F-1	J-2		Resident Representative	By ECP CCN	Rkdn	NASA	Stg Cont	As Reqd	Other
3.	**FIELD OPERATION REQUIREMENT & RECORD (FORR)** **Provide a system to plan, implement, and document quality approval, and provide evidence of completion for tasks performed in the field by Rocketdyne personnel. The FORR is prepared by Field Engineering to detail the requirements of a specific engine/GSE/component task. When approved by NASA, the FORR is authority for Rocketdyne to perform the work specified on the FORR. When the task is completed and approved on the FORR, the FORR constitutes a Certificate of Completion.**	**Forms: 612-D-15 & 612-D-16**	X	X	X		**(NASA Management at site)**		X			X	
4.	**ENGINEERING CHANGE PROPOSAL/PROPOSED OPERATING INSTRUCTION CHANGE NOTICE (ECP/POICN)** **Provide a positive system for obtaining Rocketdyne Engineering and NASA approval of proposed changes to the requirements contained in section I and II of the Operating Instructions Manuals. The POICN becomes an attachment to an ECP and is processed through the formal ECP channels. Upon approval the POICN is issued as an OICN for inclusion in the Operating Instructions Manual.**	**(Numbered consecutively by program)**	X	X		X		X	X	X	X	X	
5.	ILLUSTRATED PARTS BREAKDOWN MANUAL (IPB) **Provide identification and interrelationship of engine parts, aid in the requisition of replacement parts, and provide recommended repair/ recoverability codes.**	R-3620-4 R-3896-4 R-3825-4	X	X	X	X X X	X X X		X X X	X X X	X X X	X X X	
6.	LIST OF TIME SENSITIVE ITEMS (LOTSI) **To identify time-sensitive (limited life) items containing synthetic rubber, items subject to a preinstallation or periodic retest, service life based on cycles, seconds of operation or starts, periodic servicing, ordnance service life, and storage and usability requirements for compounds.**	R-8720	X	X	X				X			X	
7.	ROCKETDYNE AUTOMATED PACKAGING SYSTEM (RAPS) LIST **Identify the elements necessary to prepare a component or part for shipment or storage.**	**(None)**	X	X	X	X			X			X	

Table 6-1. Support Documentation Summary (Sheet 5 of 8)

Item No.	Purpose	Report/ Form No.	Program Application			Contract Req't	NASA Approval		Formal Distribution			Update Frequency	
			H-1	F-1	J-2		Resident Representative	By ECP CCN	Rkdn	NASA	Stg Cont	As Reqd	Other
8.	RECOMMENDED SUPPORT PARTS LIST (RSPL) Provide a list of recommended hardware necessary to support the engine programs. The list is developed by Rocketdyne Spares Management based on an analysis of maintenance requirements, site capabilities, and stage scheduling, and is submitted to NASA for approval. Upon approval, NASA issues a Supplemental Agreement, and procurement procedures are initiated.	(None)	X	X	X	X	X		X	X		X	
9.	REQUEST FOR DISPOSITION (RFD) Provide NASA with Rocketdyne's recommendation and description of work to be performed on an item of hardware for a specific situation. The form is prepared by Spares Management. Upon approval by NASA, Spares Management initiates the effort necessary to comply with the disposition.	Form 55-0016	X	X	X	X	X		X	X		X	
10.	INSPECTION AND DISPOSITION REPORT (IDR) Document the condition of a discrepant component/part after Rocketdyne manufacturing has completed disassembly and inspection. It defines in detail all discrepancies detected and describes a disposition for each.	Forms 601-U-2 & 601-U-4	X	X	X		X		X			X	
11.	LOGISTICS HARDWARE RELEASE (SHOP RELEASE) Authorize Rocketdyne Manufacturing to perform overhaul, repair, and modification tasks, and Purchasing to perform procurement tasks for Logistics. Each release contains specific details relative to the basic task, plus shipping instructions and schedules.	Form 610-F-14 (Listed in R-8735)	X	X	X	X	X		X	X		X	
12.	ENGINE LOG BOOK Provide official document for recording the operational status, configuration, and transfer records of the engine from delivery to launch. The official log book accompanies the engine. A duplicate log book is maintained by Rocketdyne Field Engineering to provide Rocketdyne with engine status information.	(Corresponds to Engine Serial No.)	X	X	X	X			(Engine Custodian receives official log book)			(Contained in Operating Instructions Manual)	
13.	ENGINE LOG BOOK DATA TRANSMITTAL SHEETS Convey engine status information for inclusion in the Engine Log Book. All Modification Instruction and EFIRs completed by Rocketdyne personnel, plus certain tasks done in accordance with FTVPs, require the completion of this form and subsequent distribution to the custodian of the log book.	(Corresponds to applicable FORR No.)	X	X	X				X		X	X	

Table 6-1. Support Documentation Summary (Sheet 6 of 8)

Item No.	Purpose	Report/ Form No.	Program Application H-1	F-1	J-2	Contract Req't	NASA Approval: Resident Representative	By ECP CCN	Formal Distribution: Rkdn	NASA	Stg Cont	Update Frequency: As Reqd	Other
14.	COMPONENT TEST RECORD (CTR) Provide functional test data on specific serialized engine components which are subject to field maintenance, repair, or periodic functional testing. The CTRs for installed components are kept in the Engine Log Book. CTRs for uninstalled (spare) components must accompany the component whenever it is transferred.	(None)	X	X					X		X	X	
15.	GSE MAINTENANCE RECORDS Provide a maintenance record system for periodic maintenance, inspections, and modifications of GSE at field sites. Also applicable to F-1 T-tooling at field sites. These records do not include calibration data; calibration records are maintained by the on-site calibration recall system.	Form 612-D-20	X	X	X				X		X	X	
	DISCREPANCY REPORTING DOCUMENTATION												
1.	UNSATISFACTORY CONDITION REPORT (UCR) To support the Reliability Program Plan, R-7130, the UCR provides a system for reporting unsatisfactory conditions on GFP in the field and at Canoga Park, errors in authorized procedures, and human errors that cause unsatisfactory conditions. (Not all discrepancies are recorded on UCRs; the criteria for determining which type is described in the LOM.)	Forms 610-C-140 or 610-C-156	X	X	X				X	X			
2.	FAILURE ANALYSIS REPORT (FAR) (FIELD USE) Provide a record of the analysis of an unsatisfactory condition reported by a UCR. The analysis and record are, in this case, completed by Field Engineering and/or the customer.	Form 609P-2	X	X	X				X				
3.	FIELD INSPECTION DISCREPANCY AND CORRECTION RECORD (FIDCR) The FIDCR is an attachment to the FORR work package. It provides a record of discrepancies noted during performance of the FORR task and the action taken to rectify or disposition them. Only discrepancies directly related to the FORR work package are recorded. (Use of the FIDCR does not negate the requirement for a UCR if the discrepancy satisfies UCR requirements.)	Form 612-D-17	X	X	X				X			X	
4.	FIELD INFORMATION REQUEST (FIR) Provide an authoritative, traceable record of field problems that may have a program impact, create a hazard to hardware or personnel, or require Home Office coordination and resolution. (The FIR may duplicate information that has been reported on a UCR or PCS. Refer to the LOM to determine when each form should be used.)	(Numbered consecutively by program, site, & Year)	X	X	X				X			X	

Table 6-1. Support Documentation Summary (Sheet 7 of 8)

Item No.	Purpose	Report/ Form No.	Program Application H-1	Program Application F-1	Program Application J-2	Contract Req't	NASA Approval: Resident Representative	NASA Approval: By ECP CCN	Formal Distribution: Rkdn	Formal Distribution: NASA	Formal Distribution: Stg Cont	Update Frequency: As Reqd	Update Frequency: Other
5.	PUBLICATION CHANGE SUGGESTION (PCS) Provide a standard positive method for reporting apparent or suspected discrepancies in, or suggested improvements to, data produced by Logistics Product Support and Administrative Support Services and provide timely, coordinated authoritative replies.	Form 609K-11	X	X	X				X			X	
	PROGRAM STATUS AND INFORMATION DOCUMENTATION												
1.	CONFIGURATION IDENTIFICATION & STATUS REPORT List the engines, by serial number, assigned to the program and indicate their allocation and configuration status and identify the current associated technical documentation, kit delivery schedules, modifications, special tasks, and Apollo/Skylab vehicle schedules. Also provides configuration and location information for GSE on the F-1 and J-2 programs.	R-7392	X			X			X	X	X	X	
		R-5857		X		X			X	X	X	X	
		R-5788			X	X			X	X	X	X	
2.	DATA MANUALS Provide engine design and performance information to the stage engineer and descriptive and operational information to the technician to acquaint him with the construction, configuration, and function of the engine and its components. Also provide the primary source data for training discussions and handout material.	R-3620-1	X			X	X		X	X	X	X	
		R-3620-1A	X			X	X		X	X	X	(Negotiation req'd for update)	
		R-3896-1		X		X	X		X	X	X	X	
		R-3825-1			X	X	X		X	X	X	X	
3.	TRAINING DATA Training data, consisting of data available to students and customer (excluding data used to prepare and manage a course of instruction), provides information to familiarize personnel with particular aspects of engine and GSE design and operation. The data is generally considered supplementary to classroom activities.	(None)	X	X	X				(As Required)			X	

Table 6-1. Support Documentation Summary (Sheet 8 of 8)

Item No.	Purpose	Report/ Form No.	Program Application			Contract Req't	NASA Approval		Formal Distribution			Update Frequency	
			H-1	F-1	J-2		Resident Representative	By ECP CCN	Rkdn	NASA	Stg Cont	As Reqd	Other
4	**ACTIVITY REPORTS** **Provide an interchange of information between home-office functional elements and field sites. The reports describe changes in program and hardware status that have occurred since the last reporting period, and list accomplishments, problems, and general schedule information.**	**(None)**	X	X	X				X				**Wkly**
5.	**UCR/FAR SATURN ENGINE STATUS REPORT** **Provide a description and status of all open UCRs and UCRs that have been closed since the last report period.**	**(None)**	X	X	X	X	X		X	X			**Qtly**
6.	**FIELD INFORMATION RECORD (FIR)** **Provide an authoritative method of recording and transmitting information for record purposes only between the home office and field sites.**	**(Numbered consecutively by program site, and year)**	X	X	X				X			X	
7.	**LOGISTICS INFORMATION BULLETIN (LIB)** **Disseminate skills-type information on technical subjects and subjects of general interest. LIBs supplement other technical documentation, however, LIBs are not the authority for making changes on any Rocketdyne product and do not supersede any existing field data sources.**	**LIB-(yr)-(No.) Ex: LIB-71-3**	X	X	X				X			X	

SECTION VII

SIGNIFICANT TIME REQUIREMENTS

7.1 GENERAL.

This section identifies and defines the requirements essential to the management of limited-life hardware and materials, and component periodic and preinstallation retest, reinspection or servicing, GSE test equipment and tool calibration, and personnel skills certification. Limited-life hardware and materials includes any engine, assembly, subassembly, component, part, kit, loose equipment, material such as synthetic rubber, ordnance, or compounds that have a service life sensitive to operational seconds, cycles, or elapsed time. Periodic and preinstallation retest, reinspection, and servicing requirements for spare engine components are defined in paragraphs 7.11.1 through 7.11.7. Documentation supporting these requirements is listed in table 7-1.

7.2 LIMITED-LIFE HARDWARE AND MATERIALS.

7.2.1 SYNTHETIC RUBBER SUBJECT TO AGE CONTROL.

Materials subject to age control are made primarily from the Buna-N compounds. Table 7-2 identifies the specifications of the parts and assemblies made of or containing synthetic rubber. Except for those deviations listed in the following paragraph, any part or assembly manufactured to the specifications listed in table 7-2 is subject to age control.

GSE, or other equipment not required for prelaunch servicing, fueling, and launch, are not subject to age control. Dielectric materials, composite flat gasket materials, dust seals, and mountings are excluded from age control.

Material manufactured from silicone, neoprene, butyl, viton, Teflon TFE, Teflon FEP, Mylar, or KEL-F are not subject to age control.

Table 7-1. References

Contractor Responsibilities for Use With NASA Contracts, Section XI (MSFC-STD-105A and Amendment No. 4) Age Control of Synthetic Rubber, R-3950A

Field Quality Assurance Manual, 578-D-5

List of Time-Sensitive Items Report, R-8720

MSFC Component Retest Requirements for Spares

Process Specification RA0115-122, Age Control and Marking for Synthetic Rubber Parts, and Assemblies Containing Synthetic Rubber Parts

Process Specification RA0116-096, Package Marking for Customer Shipment

Rocketdyne Automated Packaging System (RAPS) Report

Configuration Identification & Status Reports; R-5857 for F-1, R-7392 for H-1, and R-5788 for J-2

Logistics Operating Manual,

Rocketdyne Operating Policies, Section J-515, Component Shelf Life

Quality Assurance Manual, Section R-11,

Rocketdyne Standards Manual,

Technical Manuals; R-3896 series for F-1, R-3620 for H-1, and R-3825 series for J-2

Specification STO116GA00020, O-Ring and Other Rubber Items, Packaging, Packing, and Marking Requirements for Shipment

Table 7-2. Specifications

Parts and assemblies made of or containing synthetic rubber conforming to the listed specifications are subject to age control:

MIL-P-5315
MIL-P-5510
MIL-P-5516
MIL-R-6855, Class I
MIL-R-7362
MIL-P-25732
AMS 7260
AMS 7270
AMS 7271
AMS 7272
AMS 7274

Hoses and hose assemblies conforming to the following specifications are subject to age control:

MIL-H-5593
MIL-H-6000
MIL-H-7061
MIL-H-7938
MIL-H-8788
MIL-H-8790
MIL-H-8794
MIL-H-8795

7.2.1.1 SHELF/INSTALLED LIFE FOR SYNTHETIC RUBBER. Synthetic rubber material may be stored for a maximum period of twelve (12) quarters from the time of cure date.

Assemblies with time-sensitive synthetic rubber material have a maximum stored/installed life of 40 quarters except for those used in RP-1 hydraulic control systems that are exposed to RP-1 for extended time periods. The maximum acceptable installed life for RP-1 hydraulic control synthetic rubber items is 32 quarters as defined in Engine Operating Instructions Manual R-3896-11.

7.2.1.2 REQUIREMENTS FOR CONTROLLING SYNTHETIC RUBBER ITEMS. Requirements for synthetic rubber to be controlled on NASA Programs are in MSFC Specification titled, "Synthetic Rubber, Age Control of, Standard For" (MSFC-STD-105A); and contractually implemented at Rocketdyne in the document titled, "Contractual Responsibility for Use With NASA Contracts" (R-3950A, section XI). Rocketdyne Operating Policy titled "Component Shelf Life "establishes organizational responsibilities for determining life, package marking, storage, and inspection of limited-life hardware. Rocketdyne internal operations hardware life limit requirements are in Process Specifications entitled, "Age Control and Marking for Synthetic Rubber Goods and Assemblies Containing Synthetic Rubber Parts."

Requirements for synthetic rubber control within Logistics are implemented through procedures in the Logistics Operating Manual, Field Quality Assurance Manual, and technical manuals.

On F-1 and J-2 engines, the dates of the oldest component on engines installed in flight stages and spare engines are in the Configuration Identification & Status Reports.

7.2.2 REQUIREMENTS FOR OPERATIONAL LIMITS OF HARDWARE.

The engine firing time (seconds), and component cycling time are recorded in the Engine Log Book and maintained continuously. Separate and cumulative times are recorded for firing and cycle time. Operational limits

of hardware are listed in the engine operating manuals (R-3896-11 for F-1, R-3620-11 for H-1, R-3825-1B for J-2), and the actual operations that are life-limited are on data forms in the Engine Log Book that accompanies each engine. Field Operations personnel continually review and monitor these items during engine tests.

7.2.3 REQUIREMENTS FOR CONTROLLING COMPOUNDS.

Selected compounds are subject to a limited storage period from manufacturing date. If necessary, compounds exceeding their storage life may be tested for usability or recertified and the storage period extended. (Refer to R-3896-3 for F-1, R-3620-3 for H-1, and R-3825-3 for J-2.) Determining usability of compounds before use may also be required even though the item has not exceeded its storage life, if the compound appears unusable.

7.2.4 ENGINE ORDNANCE SERVICE LIFE.

The service life established for each item of ordnance is controlled in accordance with the engine technical manuals.

System Start Sets/Ordnance is procured and delivered to provide maximum storage life in support of launch schedules. Packaging, stock surveillance, and issuance is controlled similarly to other limited-life hardware.

7.3 PACKAGING AND PRESERVING.

Rocketdyne Operating Policy requires that a tabulation of hardware with life limits be prepared as part of the Rocketdyne Automated Packaging System (RAPS). A component is packaged and preserved in accordance with RAPS.

7.4 REPORTS FOR TIME-SENSITIVE ITEMS.

7.4.1 ROCKETDYNE AUTOMATED PACKAGING SYSTEM (RAPS) REPORT.

The RAPS report is an IBM tab that contains all the data needed to package and preserve parts. Service life expiration data for packaging labels of selected spares is also given.

The RAPS report and manufacturing record received with the part enable shipping personnel to prepare, package, preserve, and identify on the Acceptance Label all required information for packaging and shipping GFP items subject to limited life. Age control data on the Acceptance Label denotes assembly date, expiration date, date packaged, and component identification data.

Engineering establishes the requirement for synthetic rubber replacement on the drawing or in the specification. Design and Systems Engineering prepares and forwards age control data to Packaging Engineering for inclusion in the RAPS report.

7.4.2 LIST OF TIME-SENSITIVE ITEMS (LOTSI) REPORT.

The LOTSI report (R-8720) is a summary of limited-life hardware listed in technical manuals, Logistics Maintenance and Support plans, reports, bulletins, and log books. The LOTSI report is used to identify time-sensitive (limited life) items containing synthetic rubber, items subject to operational seconds/cycles, ordnance service life, spares requiring periodic desiccant inspection, and storage life for compounds. It also identifies items that are subject to retest, reinspection, and periodic servicing. The report identifies the part by part number, name, program, basis for start of life cycle, frequency of cycle in quarters or months, and disposition after expiration. The report contains blank columns to record the quantity and location of spares.

Update information comes from all Field Engineering and Logistics organizations on a LOTSI Supplemental Data Sheet. The sheet is used to request additions, changes, or deletions to the report. The report is updated as required.

7.5 REPORTING LIMITED-LIFE DATA.

7.5.1 DOCUMENTING AND REPORTING LIMITED-LIFE DATA.

The FORR data package include requirements for verifying and recording information pertaining to the maintenance of Engine Log Books.

The Log Book Data Transmittal Sheets in the FORR data package are completed and distributed after tasks for each FORR are completed. Field sites report changes for items subject to age control by a data transmittal sheet titled, "Age Control Log for Component Synthetic Rubber Items." A copy of the data transmittal sheet is attached to the copy of the FORR returned to Services at Canoga Park for inclusion in applicable Configuration Identification & Status Reports.

Milestone FORR Inspection Checklists record the oldest component assembly date during receiving and shipment and VAB rollout.

Distribution of FORRs to site personnel responsible for maintaining Engine Log Books is in accordance with LOM Instructions titled, "Field Operation Requirement & Record."

7.5.2 LAUNCH STATUS REPORTING.

Rocketdyne/NASA program management at MSFC reviews limited-life hardware at the same time other engine data is being analyzed for flight. An Engine Certification of Flight Worthiness is prepared to document the results of this review. Final signoff of the certificate is done at KSC when all ECPs, EFIRs, UCRs, tests, and checkouts have been resolved and/or successfully completed, and the engine(s) are considered to be acceptable for flight.

Engine documentation is reviewed approximately two weeks before FRR. Items subject to limited-life requirements are assessed and the results are reported by letter and at FRR.

7.5.3 DOCUMENTING AND REPORTING WAIVERS AND DEVIATIONS.

Limited-life requirements, waived while engines are in storage, require program management approval for the deviation. Waivers and deviations are documented in the Engine Log Books.

The Test Specification and Criteria (TSC) document, prepared by the stage contractor, is changed and approved for new component cycle life limits. Rocketdyne, Canoga Park, has the stage contractor implement specification and criteria changes and obtain NASA agreement. A waiver is submitted for changes not incorporated in the TSC document before launch.

Waivers and deviations for limited-life requirements that will be exceeded at the time of launch are submitted for consideration at FRR.

7.6 CHANGES TO LIMITED-LIFE REQUIREMENTS.

The approved limited-life requirements listed in Engine Log Books are changed by an ECP.

The RAPS report is changed by a RAPS Supplemental Packaging Data Form from the Engineering Project Office to Packaging Engineering.

Technical manual requirements for limited-life hardware are changed by an approved ECP, specification, or drawing change. Retest and servicing requirements are changed by program management direction.

The Logistics Operating Manual and the Field Quality Assurance Manual are changed as necessary to provide operational instructions for the control and implementation of the above changes, contract requirement changes, and program management directives.

F-1 and J-2 engine Configuration Identification & Status Reports are changed to show the oldest component assembly date when a Log Book Data Transmittal Sheet is received showing a change in the oldest component or part subject to age control.

7.7 GSE REQUIREMENTS.

7.7.1 GSE HARDWARE EXCLUDED FROM LIMITED-LIFE CONTROL.

R-3950A (referenced in paragraph 7.2.1.2) states: "Only those items, components, and assemblies comprising the actual flight vehicle, and the ground service equipment essential to the pre-launch servicing, fueling, and launching, which require age control as determined by Engineering, shall be considered a part of this standard." All Rocketdyne delivered GSE (section V) is not essential to prelaunch servicing, fueling, and launching and age control of synthetic parts is not required.

Rocketdyne-delivered GSE is controlled, however, by calibration, proof load, and pressure test requirements in Rocketdyne technical manuals.

7.7.2 GSE, TEST EQUIPMENT, AND TOOL CALIBRATION INTERVALS.

Rocketdyne Field Quality Assurance personnel maintain and monitor calibration records for all GSE, test equipment, and tools in Rocketdyne custody that require periodic calibration. Periodic calibration requirement instructions are outlined in the technical manuals. These calibration requirements are applicable to Rocketdyne delivered GSE and test equipment in the custody of the stage contractor. Field Operations personnel assist the stage contractor, as required, in complying with the calibration requirements.

7.8 through 7.8.2 (Deleted)

7.9 ENGINE REQUIREMENTS.

7.9.1 ACCEPTANCE DATA REQUIREMENTS.

The Engine Log Book identifies all age-controlled items on the engine and is the official document for recording the operational status. It has individual log sheets for recording and controlling limited-life hardware from acceptance through launch. The log book is part of the acceptance data package and is maintained after delivery by the contractor having custody of the engine.

For components containing synthetic rubber, an acceptance label on the package and an age control log sheet are included as part of the acceptance record. The log sheet has the information required by the process specification. Shipping inspection verified that component and packaging identification and markings are in accordance with drawing and packaging specifications. The data entered on the log sheet is transferred to the FORR data package and entered in the Engine Log Book when the item is installed on an engine. When specified by contract, Component Test Record data is sent with components shipped to GFP warehouses.

7.9.2 (Deleted)

7.9.3 ENGINE AGE CONTROL DATE TAG.

A new date tag is attached to the engine whenever replacing a component or part changes the oldest assembly/installation date for the engine. A marking machine is used to impression mark a strip of aluminum with the words "Oldest Assembly/Installation" followed by the oldest assembly/installation date. The strip is attached to an accessible mount strut where it is readily visible.

7.9.4 ENGINE STORAGE REQUIREMENTS.

Field Operations personnel identify, before the spare or installed engines are stored, any controlled item on the engine that will expire before the scheduled date for removal from storage or launch. Any deviation to the scheduled replacement date established is reported in accordance with paragraph 7.5.3.

7.10 SPARES REQUIREMENTS.

7.10.1 PROCURING SPARES.

Limited-life spares are procured to support projected program requirements in accordance with Spares Hardware Provisioning Plans.

New configuration spares are procured or spares removed from the inventory are replenished,based on the lead time, item usage, condemnation rates, and the available assets.

The maximum-minimum stock levels for limited-life assemblies and components maintained at the field site for limited-life items are established by frequency of use.

The maximum-minimum stock levels for O-ring/packing are based on the anticipated random replacement rate and planned servicing of assemblies and components.

Limited-life hardware is replaced with hardware of the latest compatible configuration.

Spares that have exceeded their service life and are not to the latest compatible configuration are placed in dormant storage unless they are to be overhauled.

7.10.2 WAREHOUSING SPARES.

7.10.2.1 STOCK CONTROL RECORDS. All time-sensitive items in the inventory of GFP warehouses, except at dormant storage facilities, are monitored. Separate stock record files are maintained for items subject to a shelf/installed life (synthetic rubber) and for compounds. The records identify the item by name, part number, and serial number when applicable. The records reflect the quantity, cure date, assembly/installation or manufacturing date, and expiration and reorder dates.

A file for shelf/installed life items is established for a six-month and a two-year review before expiration date, under the applicable monthly index tab. The six-month review identifies the assemblies, components, parts, etc, for which a reorder is required. The two-year review analyzes assemblies and components with two years of life remaining to determine program requirements. The item may be retained in stock or overhauled to a serviceable spare.

The records are set up by expiration date to permit use of the oldest item.

7.10.2.2 EXTENSION OF SERVICE LIFE. Synthetic rubber items used within an engine are periodically evaluated by Rocketdyne and NASA/MSFC to determine if an extension of the service life is possible. The evaluation may be based on previous test data, storage data, hardware disassembly analysis, etc. If the evaluation shows an extension of service life can be made, the contract and the Operating Instruction Manuals are changed to reflect the new requirements.

When an extension is approved, the field locations are notified by a FIR from Saturn Operations. The FIR authorizes Spares and Quality Assurance to update records and hardware to show the new expiration date and to prevent removing items from the inventory that are approaching the end of their service life. Control procedures are changed to include the new requirements, and when released, supersede the letter of authorization.

7.10.2.3 ISSUING TIME-SENSITIVE ITEMS. Materials and assemblies, approaching the end of their service life are issued first if enough service life remains to support engine mission objectives. Assemblies, components, and parts subject to age control and issued for use on an engine must not be older than the oldest component on the engine except when launch schedules indicate the hardware will be expended before the installed life of limited-life parts expires, or when directed by NASA/Rocketdyne program management. Items having a limited-cycle life must have enough cycle life remaining to support subsequent testing, checkout, and launch.

Limited-life synthetic rubber material with less than four (4) quarters is not shipped from Canoga to field sites unless needed immediately.

7.10.2.4 DISPOSITIONING ITEMS EXCEEDING STORAGE LIMITS. Components and assemblies exceeding the storage life limits established for the item are removed and condition-tagged. Low cost items are condemned locally. Components and assemblies coded unserviceable are condition-tagged and placed in stock at the field site pending disposition.

7.10.2.5 (Deleted)

7.10.3 SHIPMENT AND TRANSSHIPMENT OF GFP SPARES.

Serviceable spares transshipped from site to site are packaged and preserved in accordance with the requirement in the RAPS report and the Field Quality Assurance Manual.

Each unit and intermediate container shipped or transshipped bears age control data. Date marking for any of the following categories is applied to the intermediate and unit containers.

a. Containers with multiples of identical parts bearing different dates are marked with the earliest date only.

b. Containers with mixed parts, other than kits and sensitized materials, show no date.

c. Kit containers with mixed parts bearing different dates are marked with the earliest date only.

d. When packing two or more identical kits, the age control date shown on each kit container is the earliest dated part in the shipment.

Log sheets, Component Test Records, and condition tags accompany parts, as applicable.

Reparable limited-life items returned to Canoga Park for failure analysis are packaged and preserved in accordance with RAPS and the Field Quality Assurance Manual. The engine firing, cycling time, and expiration date for age control are entered on the condition tag. (This information is useful in determining to what extent the item must be refurbished.)

The DD Form 1149 or MSFC Form 57 shipping document shows age control dates for limited-life items.

7.11 HARDWARE RETEST, REINSPECTION, AND SERVICING.

7.11.1 PERIODIC RETEST.

To increase confidence in the reliability of engine systems, certain flight configuration engine replacement components are function-tested periodically. These components are retested to detect any malfunction attributed to extended storage periods and to verify the integrity of the spare within a specified time period before installation on an engine. A list of engine components that require retest before installation was prepared from an engineering evaluation of component failure history. The components and retest periods established by Rocketdyne are outlined in the engine technical manuals.

7.11.2 PREINSTALLATION RETEST/REINSPECTION.

Certain flight configuration engine replacement components listed in the engine technical manuals are considered to have a failure mode that may not be detected by a fixed interval checkout. These components are checked out before installation.

Parts are also visually inspected before installation. The inspection verifies that there are no contaminants or damage that will cause system degradation.

7.11.3 SERVICING.

Lubrication, preservation, and humidity indication checks for certain engine components are required at established intervals. Periodic maintenance of these components is required to prevent engine system degradation and to make sure the engine is maintained in a serviceable condition.

7.11.4 DOCUMENTING REINSPECTION AND RETEST TASKS.

A FORR is prepared in accordance with LOM Instructions for a preinstallation or periodic retest, reinspection, or servicing task. If the FORR is prepared for more than one item it includes the requirements for identifying and recording essential data for subsequent traceability of each spare.

Procedures used for visual inspection or testing ensure that system level cleanness is maintained. Repackaging is in accordance with the RAPS.

The Log Book Data Transmittal Sheets within the FORR data package is completed and distributed after each FORR is completed for hardware servicing tasks.

A Servicable Condition Tag showing next retest due date is prepared and attached to items that are retested and returned to inventory.

7.11.5 DOCUMENTING AND REPORTING WAIVERS AND DEVIATIONS.

Suspension of lubrication and preservation requirements while engines are in storage will require program management approval for the deviation. Waivers approved for servicing deviations will be documented in the Engine Log Book.

Servicing requirements that will be exceeded at the time of launch are submitted for consideration at the Flight Readiness Review (FRR).

7.11.6 WAREHOUSING OF SPARES.

7.11.6.1 STOCK CONTROL RECORDS. Stock control records are maintained for each component in the inventory of GFP warehouse that are subject to a periodic retest. The records identify the component by part number, name, and serial number when applicable. The records also include the date tested and next retest date.

The records for components requiring periodic retest and reinspection are reviewed and dispositioned monthly. The component with an expired retest and reinspection date is removed from serviceable stock and recycled for retest and reinspection in accordance with Rocketdyne technical manuals.

7.11.6.2 FIELD QUALITY ASSURANCE SURVEILLANCE. Field Site Operations Quality Assurance conducts a monthly surveillance on time-sensitive hardware to verify that retest/servicing dates are not exceeded. Surveillance of items in storage also includes a reinspection of spares for shelf life packaging desiccant, deterioration, etc.

7.11.7 LOG BOOK MAINTENANCE AND REVIEW.

Engine Log Book entries are reviewed with each receiving inspection and before shipment or launch to determine the status of time sensitive engine hardware.

The official Engine Log Book is maintained by the stage contractor. A duplicate copy of the official log book is maintained by Field Site Operations personnel.

7.12 PERSONNEL SKILLS CERTIFICATION.

Rocketdyne assigns technical personnel to field sites who are certified to perform specialized tasks necessary to satisfy Rocketdyne and NASA requirements. Personnel certified in the following specialized skills must be re-certified at the following maximum intervals.

a. Manual Brazing	6 mo
b. Stylus - Nickel Plating	6 mo
c. Solderer	6 mo
d. Soldering Inspection	6 mo
e. In-place Tube Welding	6 mo
f. Dye-Penetrant Inspection	12 mo
g. Stud Welding	6 mo
h. Resistance Welding	6 mo

The Field Manager or Resident Representative at a field site is responsible for the status of certification for personnel under his control. He monitors personnel certification due dates, arranges for personnel retraining and re-certification, and requests additional personnel with special certified skills necessary for specific maintenance tasks.

SECTION VIII

STORAGE

8.1 GENERAL.

Rocketdyne delivered products that are not correctly conditioned can deteriorate beyond a serviceable condition when exposed to various environmental conditions in storage. Therefore, storage requirements have been established and implemented by NASA and Rocketdyne. Complying with these storage requirements permits the Saturn engines, GSE, spares, and material placed in storage to be maintained within serviceable limits. The requirements for storage preparation and inspection control for Rocketdyne delivered hardware and materials are defined in documents listed in section VI. These storage requirements and all changes resulting from current engineering storage studies (paragraph 8.3.2) are complied with.

8.2 STAGE-INSTALLED ENGINE STORAGE.

The facility, environment, equipment, and inspection requirements, and the procedures for long-term storage of installed engines are in the documents listed in tables 8-1 and 8-2. Stage-installed engines in long-term storage are inspected at 30-day intervals to make sure corrosion control and the storage environment are maintained in accordance with current technical manual requirements. The engine component synthetic soft-good data in the Engine Log Books is reviewed periodically. Engine components that exceed the synthetic soft-goods limits (section VII) while the stage/engines are in storage will be replaced while the stage is in storage, or after the stage is removed from storage, as scheduled by the stage contractor. F-1 and H-1 engines in storage that have components requiring periodic servicing and preservation are handled in accordance with the current technical manual procedures.

Table 8-1. Rocketdyne Storage Requirements Documents

Item	Document No.	Title
S-IC Stage/Installed F-1 Engine	R-3896-11	F-1 Engine Operating Instructions Manual
S-IB Stage/Installed H-1 Engine	R-3620-11	H-1 Engine Operating Instructions Manual
S-II Stage/Installed J-2 Engine	R-3825-1B	J-2 Engine Operating Instructions Manual
S-IVB Stage/Installed J-2 Engine	R-3825-1B	J-2 Engine Operating Instructions Manual
F-1 GSE	R-3896-5	F-1 Engine GSE Maintenance and Operations Manual
H-1 GSE	R-3620-3	H-1 Engine Maintenance and Repair Manual
J-2 GSE	R-3825-5	J-2 Engine GSE Maintenance and Repair Manual

Table 8-2. NASA/Stage Contractor Storage Requirements Documents

Item	NASA/Contractor	Document No.	Title
S-IC Stage/ F-1 Engine	MSFC	MSFC-STD-500A	S-IC Stage Storage Plan for FTC
S-IC Stage/ F-1 Engine	MSFC	66B10932	S-IC Stage Extended Storage
S-IB Stage/ H-1 Engine	MSFC	MSFC-STD-499A	S-IB Stage Storage
S-II Stage/ J-2 Engine	MSFC	MSFC-STD-498A	S-II Stage Storage
S-II Stage/ J-2 Engine	SD-NR	SD70-555	S-II Stage KSC Storage Plan, Stages S-II-12, -13, -14, and -15
S-IVB Stage/ J-2 Engine	MDAC	GO-142	S-IVB Stage Storage Plan for FTC
Spare F-1 Engine	MSFC	66B10934	Spare F-1 Engine Storage Requirements

8.3 SINGLE ENGINE STORAGE.

8.3.1 FLIGHT SPARE ENGINE STORAGE.

F-1 and H-1 engines designated as flight spare engines for Saturn vehicles are stored at MAF; J-2 engines are stored at KSC. Before each engine is placed in storage it has the latest approved modifications and EFIRs and is in a "ready-state" condition. While in storage, the engines are maintained in a relatively moisture-free condition so minimum effort is necessary to ready the engines for use in a flight stage. When engines are placed in short-term or long-term storage, desiccants are inspected as indicated in the applicable technical manuals to ensure that the engine has not exceeded a 30 percent humidity level. Engines designated as flight spare engines are as follows:

F-1	H-1	J-2
F-2049[a]	H-4108	J-2107
F-2090[a]	H-4109	J-2146
	H-7112	
	H-7113	

8.3.2 ENGINE EVALUATION AND VERIFICATION STORAGE.

The following Saturn engines are designated to be used to assess the reliability and flight worthiness of engines after exposure to long-term storage conditions. The F-1 engines are stored at MAF. The H-1 and J-2 engines with the exception of H-1 engine H-5041 are stored at KSC. H-1 engine H-5041 is stored at MSFC.

F-1	H-1	J-2
F-2023[a]	H-4081[a]	J-2039-1
F-2036[a]	H-4107[a]	J-2103
	H-5041[b]	J-2148
	H-7097[a]	

(a) Stored with vehicle.

(b) Aging study engine.

These engines are conditioned for long-term storage to evaluate the requirements outlined in Saturn Engines Contract Operational and Flight Support Program Plan for the Apollo/Soyuz Test Project R-8300, Task A3600. Certain engines have been selected to be stored with their flight stages and will be exposed to the same storage conditions as the stage. Desiccant and corrosion control inspection are made at 30-day intervals, concurrent with stage-installed engines. Engines not stored with flight stages have been conditioned and placed in long-term storage under environmental protective covers. The single engine environmental protective cover desiccants are inspected at 30-day intervals.

8.3.3 UNASSIGNED ENGINE STORAGE.

Unassigned engines are placed in long-term storage in their present configuration with outstanding ECPs and EFIRs noted in the Configuration Identification & Status Reports. The desiccant is inspected at 30-day intervals for F-1 and J-2 engines, and 7-day intervals for H-1 engines. These engines are reviewed periodically by NASA for possible modification and use at a future date. When engines are removed from storage, all outstanding ECPs and EFIRs are incorporated and general servicing requirements are accomplished as required.

8.3.4 ENGINE REMOVAL FROM STORAGE.

Engines removed from short-term or long-term storage are inspected, checked out (unless otherwise directed by NASA), and prepared for installation into a flight stage. An engine removed from storage for modification and/or servicing is reconditioned for corrosion control before being returned to storage. When engines are removed from storage for any purpose, the servicing, soft goods, and cycle life records are reviewed to determine that the engine systems meet all serviceable requirements and a stress corrosion inspection is performed.

8.4 GROUND SUPPORT EQUIPMENT STORAGE.

GSE is currently placed in storage at various field sites supporting the Saturn Programs and at the EFL Warehouse. When an item of GSE is placed in storage at a NASA designated location, it is conditioned and stored under one of three categories of storage, as defined by Rocketdyne, such as active, short-term, or long-term. GSE placed in storage under each category is maintained in accordance with the technical manual requirements. (For information pertaining to GSE location, type, and quantity, refer to the applicable Configuration Identification & Status Report.)

8.4.1 ACTIVE GSE STORAGE.

GSE is maintained in a serviceable condition and can be used without qualification. This equipment is periodically calibrated, proof-loaded, and inspected at time-intervals established and approved for the item. GSE stored under this category is usually located at the field sites.

8.4.2 SHORT-TERM GSE STORAGE.

Serviceable GSE that is used occasionally may be placed in short-term storage for a maximum of two years. The periodic calibration, proof-loading, and servicing requirements may be waived by NASA and Rocketdyne if the following conditions are met:

a. The item receives the minimum servicing necessary when placed in storage to prevent deterioration; correct packaging and environmental controls are maintained; and an expiration date of two years is established for reinspecting, reservicing, and repackaging to verify and maintain the servicable state.

b. Calibration and proof-loading is done in accordance with the technical manual requirements before use.

8.4.3 LONG-TERM GSE STORAGE.

Inactive GSE is conditioned for long-term storage if a reactivation date has not been established or if the scheduled storage period exceeds two years. Servicing, preservation, packaging, and the environment of the storage area must be adequate to prevent deterioration with a minimum of inspection surveillance. GSE removed from long-term storage must receive a complete inspection. All calibration, proof-loading, and servicing must be done in accordance with technical manual requirements.

8.5 SPARE COMPONENT STORAGE.

Spare engine and GSE parts are packaged for storage in accordance with requirement documented in the Rocketdyne Automated Packaging System. They are controlled during storage by requirements in NASA Procurement Regulation (NASPR) appendix B. Spares are selected for storage, removal from storage, and shipment through the Spares system (section II). They are stored in warehouses at KSC and EFL. Engine ordnance is stored at Santa Susana Field Laboratory.

During storage, periodic retesting and desiccant surveillance are performed for certain spares in accordance with the requirements in section VII and as directed in approved FORRs.

When a spare component is removed from storage for use on a flight engine the remaining cycle life and soft goods life are reviewed to verify that enough life remains on the component. Before use, the components are visually inspected to determine if the component is free of contamination and is serviceable. If the component requires a preinstallation verification functional test, the testing is done as outlined in the engine technical manual before installation on the engine. If an engine component removed from storage is rejected for failure to pass inspection as a serviceable component, the component is immediately dispositioned and handled as failed GFP hardware.

8.6 EFL WAREHOUSE AND INVENTORY CONTROL.

Engines, GSE, tooling, special test equipment, and provisioned spare parts not required for the Saturn program are sent to the EFL warehouse for long-term dormant storage. Items sent to EFL from Rocketdyne facilities are preserved, packaged, boxed, or palletized as appropriate, before shipment. These items are classified as excess to contract needs as a result of: (1) contract termination of the F-1, H-1, and J-2 engines; (2) contract cancellations; or (3) provisioned spare hardware being declared excess to program forecasts. Accountable inventory records that indicate the condition, status, and quantity of this hardware are maintained by Logistics Warehouse personnel. Continuous consideration is given this hardware for possible use in current or forecasted programs. The engine and major assembly desiccants are inspected at 30-day intervals to ensure that the hardware remains relatively free of moisture. All hardware at EFL is stored in accordance with NASA Procurement Regulation, appendix B.

8.7 MATERIAL STORAGE.

8.7.1 COMPOUND STORAGE.

The shelf-life requirements of compounds (RTV, Thermolite 12, Eccobond, etc) provide the warranty limits for the storage of compounds. A compound, however, placed in a controlled storage environment can be removed from storage and used over a longer period of time than its shelf-life limits indicate. Simple tests have been devised and are used to determine the usability of age-controlled compounds at field sites. The tests are in the engine technical manuals. Quality Assurance personnel at the field sites where compounds are stored ensure that compound storage and testing is done in accordance with procedures in the engine technical manuals and supporting documentation. The storage area and containers are examined when the compound is removed from storage to determine if the immediate environment had an effect on its usability. Accepting a compound for use under the usability test criteria does not, however, recertify the compound to the original specification standards. Recertification of certain compounds, as deemed necessary by the local Quality Representative, must be returned to Rocketdyne for analysis and recertification.

8.7.2 RAW MATERIAL STORAGE.

Raw materials (paints, lubricants, fluids, gasket material, etc) used at field sites are stored in accordance with the vendor and/or NASA/ Rocketdyne requirements. When materials are received at the field site, they are inspected and the vendor/manufacturer's storage requirements are noted to ensure that the material is stored under the prescribed storage environment and conditions. A periodic audit is made to ensure that all raw materials used in support of engine, GSE, and component hardware are stored in accordance with specified requirements.

SECTION IX

FACILITIES AND INSTITUTIONAL SERVICES

This section deleted.

APPENDIX A
AUTHORIZED ENGINE REPAIR AT KSC

Unscheduled maintenance (engine repair) permitted without engineering evaluation and decision consists of removing and replacing or removing and reinstalling components and limited in-place repair. Replacement of certain components and parts can adversely affect engine performance and restrictions are imposed on replacing these components and parts. The level of engine repair permitted for H-1 and J-2 engines is specified in tables A-1 and A-2. No repair is specified for F-1 engines, since the engines are dormant and in storage.

Maintenance codes denoting repair limits in repair tables are as follows:

Maintenance Codes

RR Remove and Replace. (With a like serviceable item. Engine calibration and alinement are not affected.)

RI Remove and Reinstall. (The same item. Engine performance could be affected if the same item is not reinstalled.)

Table A-1. H-1 Engine Repair (Sheet 1 of 5)

Nomenclature	Engine Repair KSC	Remarks
ENGINE ASSEMBLY	RR	
. Propellant feed system installation		
. . Turbopump assembly	RI(a)	
. . . Oxidizer inducer	RR	
. . . Fuel inducer	RR	
. . . Oxidizer impeller	RI(a)	
. . . Fuel impeller	RI(a)	
. . . Oxidizer shaft seal	RR	Seal and mating ring must be replaced as a unit.
. . . Fuel shaft seal	RR	Seal and mating ring must be replaced as a unit.
. . . Oxidizer shaft seal mating ring	RR	Seal and mating ring must be replaced as a unit.
. . . Fuel shaft seal mating ring	RR	Seal and mating ring must be replaced as a unit.
. . . Fuel inlet adapter	RR	
. . . Oxidizer inlet adapter	RR	
. . . Oxidizer inlet liner	RR	
. . . Heater harness	RR	
. . . Turbine	RI(a)	
. . . Magnetic pickup	RR	

(a) Replacement requires hot-fire retest of engine assembly.

Table A-1. H-1 Engine Repair (Sheet 2 of 5)

Nomenclature	Engine Repair KSC	Remarks
. . . Lube filter	RR	
. . . Lube drain relief valve	RR	
. . . Gear nozzles	RR	
. . . No. 1 bearing nozzle	RR	
. . . Lube restrictor body	RR	Replacement item must be flow calibrated before installation.
. . . No. 1 bearing thermocouple	RR	
. . . Thermocouple harness	RR	
. . Turbopump forward mount	RR	
. . Main oxidizer valve	RR	
. . Oxidizer valve heater	RR	
. . Igniter fuel valve	RR	
. . Main fuel valve	RR	
. . Oxidizer joint (LOX duct)	RR	
. . Fuel duct	RR	
. . Main fuel orifice	RR(b)	
. . Main LOX orifice	RR(b)	
. . Unitized check valve	RR	

(b) Must be replaced with a calibrated, like item.

Table A-1. H-1 Engine Repair (Sheet 3 of 5)

Nomenclature	Engine Repair KSC	Remarks
. Gas generator and controls installation		
. . Gas generator control valve	RI(a)	
. . Gas generator injector	RI(a)	
. . Gas generator combustor	RI(a)	
. . Fuel bootstrap line	RR	
. . Fuel bootstrap orifice plate	RR(b)	
. . Fuel bootstrap seal plate	RR	
. . LOX bootstrap line	RR(b)	
. . LOX bootstrap orifice plate	RR(b)	
. . Engine control line quick-disconnect	RR	
. . Ignition monitor valve	RR	
. . Thrust OK pressure switch	RR	
. . Hypergol detector switch	RR	
. . Lines and manifolds (other than LOX bootstrap line)		
. . Quick-disconnect coupling	RR	

(a) Replacement requires hot-fire retest of engine assembly.
(b) Must be replaced with a calibrated, like item.

Table A-1. H-1 Engine Repair (Sheet 4 of 5)

Nomenclature	Engine Repair KSC	Remarks
. Pneumatic and lube system installation		
. . Check valves (gearcase pressurizing, GG LOX injector purge, thrust chamber fuel injector purge)	RR	
. . Gearcase pressurizing cross fitting	RR	Replacement item must be flow checked before installation.
. . LOX seal cavity purge orifice fitting	RR	Replacement item must be flow checked before installation.
. . Fuel additive blender Unit (FABU)	RR	
. . FABU heater assembly	RR	
. . Lines and manifold	RR	
. . Quick-disconnect coupling	RR	
. Thrust chamber and gimbal installation		
. . Thrust chamber assembly	RI(a)	
. . . Thrust chamber body	(c)	Field repair limited to minor tube brazing on the engine.
. . . . Aspirator (H-1D)	---	Field repair limited to minor welding on the engine.
. . . . Exhaust duct (H-1C)	RR	
. . . Thrust chamber injector	(c)	
. . . LOX dome	(c)	

(a) Replacement requires hot-fire retest of engine assembly.
(c) Removal and reinstallation requires hot-fire retest of engine.

Table A-1. H-1 Engine Repair (Sheet 5 of 5)

Nomenclature	Engine Repair KSC	Remarks
. . . Turbopump support fittings	RR	
. . . Turnbuckle assembly (H-1C)	RR	Length of replacement item must be same as original length recorded in Engine Log Book.
. . . Stabilizing lug (H-1C)	RR	
. . Gimbal assembly	RR	
. Turbine exhaust system installation		
. . Exhaust hood	RR	
. . Heat exchanger	RR	
. . Heat exchanger LOX supply line	RR	
. Electrical system installation		
. . Engine harness assembly	RR	
. Pressure-actuated seals (Naflex, all systems)	RR	Return replaced item to Rocketdyne, Canoga Park for inspection and repair.

Table A-2. J-2 Engine Repair (Sheet 1 of 11)

Nomenclature	Engine Repair KSC	Remarks
ENGINE ASSEMBLY	RR	
. Control system installation		
. . STDV control solenoid adapter assembly	RR	
. . Electrical control assembly	RR	
. . Ignition-dummy detector	RR	
. . Electrical harness assembly	RR	
. . ASI spark igniter and cable assembly		Replacement part of ASI injector assembly.
. . Gas generator spark igniter and cable assembly	RR	
. . Bleed valve control manifold assembly	RR	
. . Gas generator opening control manifold assembly	RR	
. . Ignition control manifold assembly	RR	
. . LOX dome purge manifold assembly	RR	
. . Mainstage control manifold assembly	RR	
. . OTBV control manifold assembly	RR	
. . Ignition detector probe assembly	RR	
. . Helium regulator assembly	RR	

Table A-2. J-2 Engine Repair (Sheet 2 of 11)

Nomenclature	Engine Repair KSC	Remarks
. . . 3-way helium control valve assembly	RR	
. . . 3-way helium vent control valve assembly	RR	
. . . 4-way ignition phase control valve assembly	RR	
. . . 4-way mainstage control valve assembly	RR	
. . . High pressure relief valve assembly	RR	
. . . Main regulator exhaust check valve assembly	RR	
. . . Vent port check valve assembly	RR	
. . . Helium tank vent valve filter	RR	
. . . Helium control valve filter	RR	
. . . Low temperature relief valve	RR	
. . Mainstage OK switch assembly	RR	
. . Oxidizer dome purge check valve assembly	RR	
. . Pressure-actuated purge valve assembly	RR	
. . Pressure-actuated shutoff valve assembly	RR	
. . 4-way STDV control valve assembly	RR	

Table A-2. J-2 Engine Repair (Sheet 3 of 11)

Nomenclature	Engine Repair KSC	Remarks
. Customer connect installation		
. . Bracket assembly	RR	
. . Electrical harness assembly	RR	
. . Fluid lines hose assembly	RR	
. . Fuel jacket purge check valve assembly	RR	
. . Engine purge check valve assembly	RR	
. Gas generator and exhaust system installation		
. . Fuel turbine exhaust duct assembly	RR	
. . Temperature transducer (turbine outlet)	RR	
. . Heat exchanger oxidizer turbine exhaust	RI(a)	
. . Oxidizer turbine bypass valve assembly	RR	If replaced, orifice nozzle must be removed and installed in replacement unit.
. . Variable resistor	RR	
. . Low temperature relief valve assembly	RR	
. Instrumentation installation		
. . Electrical harness assembly	RR	

(a) Replacement requires Rocketdyne engineering evaluation and decision and NASA EPO approval.

Table A-2. J-2 Engine Repair (Sheet 4 of 11)

Nomenclature	Engine Repair KSC	Remarks
. . Auxiliary flight instrumentation package assembly	RR	
. . . Pressure transducers	RR	
. . Primary flight instrumentation package assembly	RR	
. . . Pressure transducers	RR	
. Loose equipment		
. . Quill shaft	RR	
. Propellant feed system installation		
. . Helium heat exchanger inlet line	RR	
. . Oxidizer bleed valve and boot-strap line assembly	RI(a)	
. . Fuel inlet low pressure duct assembly	RR	
. . Fuel high pressure thrust chamber inlet duct assembly	RR	Replacement requires flow calibration.
. . Fuel high pressure turbopump discharge duct assembly	RR	
. . Oxidizer inlet low pressure duct assembly	RR	
. . Oxidizer high pressure thrust chamber inlet duct assembly	RR	Replacement requires flow calibration.
. . Oxidizer high pressure turbopump discharge duct assembly	RR	

(a) Replacement requires Rocketdyne engineering evaluation and decision and NASA EPO approval.

Table A-2. J-2 Engine Repair (Sheet 5 of 11)

Nomenclature	Engine Repair KSC	Remarks
. . Fuel flowmeter	RR	Replacement to be flow calibrated with duct assembly.
. . Oxidizer flowmeter	RR	Replacement to be flow calibrated with duct assembly.
. . Fuel flow straightener	RR	
. . Oxidizer flow straightener	RR	
. . Fuel bootstrap hose assembly	RR	
. . Oxidizer bootstrap line assembly	RI(a)	
. . Oxidizer heat exchanger inlet line assembly	RR	
. . Lower fuel ASI line assembly	RR	
. . Fuel turbopump line assembly	RR	
. . Oxidizer turbopump mount assembly	RR	
. . Fuel high pressure duct tie-rod	RR	
. . Fuel turbopump assembly	RI(a)	Field repair limited to on-the-engine removal and replacement of sub-assemblies and parts.
. . . Rotor stud	RI	
. . . Turbine torque plate	RR	
. . . Second-stage turbine wheel assembly	RI	

(a) Replacement requires Rocketdyne engineering evaluation and decision and NASA EPO approval.

Table A-2. J-2 Engine Repair (Sheet 6 of 11)

Nomenclature	Engine Repair KSC	Remarks
. . . Turbine stator retainer	RI	
. . . Second-stage turbine seal assembly (honeycomb)	RR	
. . . Turbine stator blade assembly	RI	
. . . First-stage turbine seal assembly (honeycomb)	RI(a)	
. . . Turbine stator ring assembly	RI	
. . . First-stage turbine wheel assembly	RI	
. . . Circumferential turbine seal	RR	Mating ring must be replaced when seal is replaced.
. . . Turbine seal gasket	RR	
. . . Secondary mating ring	RR	
. . . Secondary seal assembly	RR	Mating ring must be replaced when seal is replaced.
. . . Secondary seal shim	RR	
. . . Mating ring spacer	RI	
. . . Omniseal	RR	
. . . Primary mating ring	RR	
. . . Primary seal assembly	RR	Mating ring must be replaced when seal is replaced.

(a) Replacement requires Rocketdyne engineering evaluation and decision and NASA EPO approval.

Table A-2. J-2 Engine Repair (Sheet 7 of 11)

Nomenclature	Engine Repair KSC	Remarks
. . . Primary seal shim	RR	
. . . Speed transducer	RR	
. . . Temperature transducer	RR	
. . . Gas generator oxidizer injector poppet assembly	RI	
. . . Gas generator control valve assembly	RR	
. . . . Access cover	RI	
. . . . Variable resistor	RR	
. . . . Vent port check valve assembly	RR	
. . Oxidizer turbopump assembly	RI(a)	Field repair limited to on-the-engine removal and replacement of sub-assemblies and parts.
. . . Inducer shroud restraining ring	RR	
. . . Inducer shroud (KEL-F)	RI	
. . . Inducer shroud carrier assembly	RI(a)(b)	Field repair limited to threaded insert replacement.
. . . Inducer shroud carrier retainer	RR	
. . . Seal carrier piston ring	RR	

(a) Replacement requires Rocketdyne engineering evaluation and decision and NASA EPO approval.
(b) Replacement requires hot-fire retest of engine assembly or component.

Table A-2. J-2 Engine Repair (Sheet 8 of 11)

Nomenclature	Engine Repair KSC	Remarks
. . . Impeller inlet seal retaining nut	RR	
. . . Impeller inlet seal assembly	RI(a)(b)	
. . . Inducer bolt	RR	
. . . Inducer	RI(a)(b)	
. . . Impeller	RI(a)(b)	
. . . Impeller outlet seal retaining nut	RR	
. . . Impeller outlet seal assembly	RI(a)(b)	
. . . Accessory drive adapter	RI	
. . . Turbine stator blade assembly	RI(a)(b)	
. . . Turbine wheel retaining bolts	RR	Any two of the six bolts may be replaced if the total weight is within 0.5 gram of the bolts replaced.
. . . Stator bolts	RR	
. . . Turbine stator mounting ring assembly	RI(a)(b)	
. . . Turbine stator clamp ring assembly	RI(a)(b)	
. . . Temperature transducer (turbine inlet)	RR	

(a) Replacement requires Rocketdyne engineering evaluation and decision and NASA EPO approval.
(b) Replacement requires hot-fire retest of engine assembly or component.

Table A-2. J-2 Engine Repair (Sheet 9 of 11)

Nomenclature	Engine Repair KSC	Remarks
. . . First-stage turbine wheel	RI(a)(b)	
. . . Second-stage turbine wheel	RI(a)(b)	
. . Antiflood check valve assembly	RR	
. . Augmented spark igniter valve assembly	RR	
. . Fuel bleed valve assembly	RR	
. . Main fuel valve assembly	RR	
. . . Position indicator	RR	
. . . Low temperature relief valve assembly	RR	
. . Main oxidizer valve assembly	RR(c)	
. . . Position indicator assembly	RR	
. . . Low temperature relief valve assembly	RR	
. . . Compensator orifice	RR	Replacement orifice size determined by calibration.
. . . Filter housing assembly	RR	
. . Oxidizer bleed valve assembly	RR	
. . . Oxidizer bleed valve temperature transducer	RR	

(a) Replacement requires Rocketdyne engineering evaluation and decision and NASA EPO approval.
(b) Replacement requires hot-fire retest of engine assembly or component.
(c) Center engine on SII stage has restricted access.

Table A-2. J-2 Engine Repair (Sheet 10 of 11)

Nomenclature	Engine Repair KSC	Remarks
. . Mixture ratio control valve assembly	RR	
. . . Valve position transducer	RR	
. . . Low temperature relief valve assembly	RR	
. . . Vent port check valve assembly	RR	
. . . 3-way valve assembly	RR	
. . Heat exchanger inlet line	RR	
. Start system installation		
. . Helium tank cover assembly	RR	
. . STDV hose assembly	RR	
. . Start tank refill line assembly (gaseous)	RR	
. . Start tank support links	RR	
. . Start tank refill manifold assembly (liquid)	RR	
. . Start tank struts	RR	
. . Integral start/helium tank assembly	RR(c)	
. . Start tank discharge valve assembly	RR	
. . . Variable resistor	RR	

(c) Center engine on SII stage has restricted access.

Table A-2. J-2 Engine Repair (Sheet 11 of 11)

Nomenclature	Engine Repair KSC	Remarks
. . . Vent port check valve assembly	RR	
. . Start tank support and fill valve assembly	RR	
. . . Emergency vent valve assembly	RR	
. . Start tank vent and relief valve assembly	RR(c)	
. Thrust chamber and gimbal installation		
. . ASI assembly	RR	
. . Gimbal boot assembly	RR	
. . Thrust chamber assembly		
. . . Thrust chamber body assembly		Field repair limited to minor tube brazing/ welding and insulation repair on engine.
. . . Thrust chamber injector assembly	RI(a)	Replacement affects engine calibration and alinement.
. . . Thrust chamber temperature transducer	RR	
. . Gimbal assembly	RI(a)	Replacement affects engine alinement.
. Pressure-actuated seals (Naflex, all systems)	RR	Return replaced item to Rocketdyne, Canoga Park for inspection and repair.

(a) Replacement requires Rocketdyne engineering evaluation and decision and NASA EPO approval.
(c) Center engine on SII stage has restricted access.

APPENDIX B

ENGINE COMPONENT REPLACEMENT

This appendix deleted.

APPENDIX C

SUPPORT EQUIPMENT LISTS

The following tables list Saturn engine support equipment items that are necessary to fulfill the requirements outlined in section V.

Table C-1. Support Equipment for F-1 Engines (Sheet 1 of 8)

Number	Nomenclature	Use
AT1385883	Pressure Adapter	Perform pressure tests on thrust OK pressure switches.
G2030	Oxidizer Dome Flushing Kit	Blend trichloroethylene and gaseous nitrogen into a fog for cleaning dome and injector and GG ball valve and injector; a portable manifold unit.
G2035	TIS Installation Set	Install thermal installation.
G2037	Fuel Drainage Kit	Drain fuel from engine after aborted launch, or any time fuel has entered engine system.
G2038	Temperature Transducer Installer and Remover Kit	Install or remove temperature transducers.
G2039	Scavenge Pump	Remove fuel and preservative from turbopump lubrication system during preservation of turbopump.
G3104	Pneumatic Flow Tester	Measure pneumatic leakage flowrates.
G3130	Pneumatic Flow Monitor (Fuel)	Measure upstream flowrates during leak-tests; a multi-tube flowmeter set.

Table C-1. Support Equipment for F-1 Engines (Sheet 2 of 8)

Number	Nomenclature	Use
G3131	Pneumatic Flow Monitor (Oxidizer)	Measure upstream flowrates during leak-tests; a multi-tube flowmeter set.
G3135	Hypergol System Tool Kit	Test actuation of hypergol switch and to plug hypergol container during leak-and function-tests while purging hypergol container.
G3136	Thrust Chamber Throat Plug	Seal TC throat area during leak-tests.
G3144	Turbine Exhaust Exit Pressure Check Fixture	Seal turbine exhaust exit during leak-test.
G3153	High Voltage Igniter Tester	Test high voltage igniters.
G4044	Engine Air Transport Handler	Transport engine.
G4047	Engine Cover	Cover engine after removal from stage and during storage or shipment.
G4048	Thrust Chamber Protective Cover	Protect thrust chamber tubes.
G4049	Engine Vertical Installer	Install or remove engine or nozzle extension from a vertical stage.
G4050	Engine Rotating Sling	Rotate and position engine.
G4052	Engine Handler Sling	Lift air transport handler with or without engine installed, or lift G4080, G4081, and nozzle extension.
G4059	Gimbal Bearing Lock	Hold gimbal stationary during shipment.

Table C-1. Support Equipment for F-1 Engines (Sheet 3 of 8)

Number	Nomenclature	Use
G4060	Vertical Installer Sling	Lift G4049.
G4067	Engine Shipping Buttress	Secure engine and handler in airplace during air shipment.
G4077	Vertical Installer Adapter	Support Vertical Installer during shipping and storage.
G4079	Nozzle Extension Alinement Tool	Aline nozzle extension and thrust chamber flanges for nozzle installation.
G4080	Nozzle Extension Handling Fixture	Handle thrust chamber nozzle extension.
G4081	Nozzle Extension Handling Adapter	Transport nozzle extension.
G4087	Band Clamp Tool Kit	Compress band clamps during installation.
G4088 or 99-9026814	Turbopump Shaft Preload Fixture	Prevent excessive vibrating of turbopump shaft during shipping.
G4089	Thrust Chamber Throat Security Closure	Prevent unauthorized access to thrust chamber injector.
Model MT-109	Flowmeter (3/4-inch inlet and outlet)	Provide a way to measure flow during timing and actuation tests.
Model 630A	Multimeter	Perform electrical continuity tests.
Model 1630C	Megohmeter	Perform electrical high resistance tests.
T-5021812	Depth Micrometer	Take depth dimensions of turbopump during repair.

Table C-1. Support Equipment for F-1 Engines (Sheet 4 of 8)

Number	Nomenclature	Use
T-5023955	Special Wrench	Install and remove bolts that secure gas generator outlet flange to turbine inlet.
T-5026302	Pressure Test Fixture	Seal engine control valve ports during component leak and function testing.
T-5026432	Torque Bar	Hold turbopump shaft stationary when removing and/or installing and torquing oxidizer inducer retaining bolt.
T-5026436	Protection Sleeve	Protect oxidizer pump volute from damage during maintenance.
T-5026440	Pressure Test Fixture	Seal oxidizer volute area around primary seal during leak test of primary and intermediate seals.
T-5028673	Lift and Holding Tool	Lift and handle oxidizer pump inlet during removal and installation of inlet.
T-5028674	Ring Compressor	Compress and hold oxidizer pump inlet piston rings in place during installation of inlet.
T-5028675	Pressure Test Fixture	Pressure-test turbopump intermediate seal.
T-5028680	Wrench	Remove and install oxidizer pump mating ring nut.
T-5028689	Pressure Test Fixture	Seal oxidizer pump outlet flanges during an oxidizer pump leak test.

Table C-1. Support Equipment for F-1 Engines (Sheet 5 of 8)

Number	Nomenclature	Use
T-5029452	Hydraulic Torque Tool	Torque oxidizer retaining bolt up to 4,000 ft-lb and to loosen bolt.
T-5029467	Torque and Inspection Tool	Measure bolt stretch when torquing turbopump inducer locking bolt. (Similar to adapter T-5035940.)
T-5029619	Torque Adapter	Primarily to remove, and install and torque bolts that secure propellant valves and ducts to engine.
T-5029642	Special Wrench Adapter	Remove and install nuts that secure GG ball valve oxidizer outlet to GG injector.
T-5031167	Pressure Test Fixture	Seal checkout valve ports during component leak- and function-testing.
T-5031700	Pressure Test Fixture	Seal engine control valve ports during component leak and function-testing.
T-5035571	Pressure Test Fixture	Perform pressure tests on propellant feed (oxidizer) system of engine.
T-5035912	Pressure Test Fixture	Seal ports while pressure testing turbopump bearing coolant control valve and valve to No. 1 and No. 2 bearing lube feed tubes.
T-5035933	Inducer Puller	Remove turbopump oxidizer inducer from turbopump shaft.

Table C-1. Support Equipment for F-1 Engines (Sheet 6 of 8)

Number	Nomenclature	Use
T-5035934	Impeller Coupling Puller	Pull turbopump LOX impeller coupling from turbopump shaft.
T-5035937	LOX Inducer Cap Puller	Remove fairing cap from bolt in end of turbopump shaft.
T-5035940	Adapter	Measure bolt stretch when torquing turbopump inducer locking bolt. (Identical to T-5029467 except for length).
T-5036718	Assembly Tool	Install filter in control body of hydraulic control valve.
T-5037801	Pressure Text Fixture	Proof-, leak-, and function-test inert prefill check valve.
T-5037803	Holding Fixture	Press bearings onto ball shafts of checkout valve.
T-5037817	Inspection Check Fixture	Measure distance from retainer to ball to establish shim thickness on assembly checkout valve.
T-5037831	Ball Position Indicator	Adapt a torque wrench to ball shaft and indicate position of ball during torque-check of the checkout valve.
T-5037832	Inspection Check Fixture	Measure gap between cover and switch foot and housing and finger to determine thickness of shim during installation of switch into GG ball valve.
T-5039241	Pressure Test Fixture	Seal fuel overboard drain lines during leak test of bearing coolant system.

Table C-1. Support Equipment for F-1 Engines (Sheet 7 of 8)

Number	Nomenclature	Use
T-5041233	Gimbal Yoke Alinement	Aline gimbal sections of hydraulic and pressurization system wrap-around lines.
T-5041258	Dummy Seal Set	Simulate seal plates during a fit-check of fuel and oxidizer high-pressure ducts.
T-5041500	Actuator Installation Tool	Remove and install actuator from a cylinder of four-way solenoid valve.
T-5041501	Assembly Jig	Install parts in a cylinder of engine control valve.
T-5041521	Pressure Test Fixture	Seal openings of three-way solenoid valve for pressure testing.
T-5041812	Clearance Pins	Measure clearance between turbopump oxidizer inducer and wall of oxidizer inlet.
T-5043413	Shim	Simulate fuel-valve-to-fuel-manifold seal plate or oxidizer-valve-to-oxidizer-dome seal plate during alinement of engine propellant valves and ducts.
T-5044645	Seal Installation Tool	Install a tool on turbopump oxidizer shaft.
T-5044743	Alinement Gage	Determine that allowable lateral misalinement of line flanges is not exceeded.
T-5046431	Washer	Obtain acceptable axial dimensions between collar of shaft and tubular spacer of TC throat plug when throat plug is being installed in TC.

Table C-1. Support Equipment for F-1 Engines (Sheet 8 of 8)

Number	Nomenclature	Use
T-5048259	Solenoid Removal Tool	Remove and install solenoids in four-way solenoid valve.
1432-T	Decade Resistance Box	Perform electrical resistance test.
19065	Filter	Filter hydraulic fluid when testing start and stop solenoids.
88-557487	Check Valve Cap	Pressure-test check valve after repair.
9026560	Welding Set, Spot-Weld	Spot-weld materials less than 0.004 inch thick.
9026561	Welding Set, Spot-Weld	Spot-weld materials 0.004 to 0.032 inch thick.
9026570	Welding Set, Stud Welding	Percussion and fusion stud welding.
9026622	Inert Igniter	During CDDT.
99-9012908	Fuel Drain Vent Adapter Kit	Drain fuel from engines installed in stage.
99-9014130	Engine Environmental Cover Set	Protect thermal insulation, engine and nozzle extension from impingement of liquids.

Table C-2. Support Equipment for H-1 Engines (Sheet 1 of 6)

Number	Nomenclature	Use
	Flowmeters: (Accuracy of ±10% of Full Scale) 0-5 Scim	Leak-check FABU, MOV, MFV, IMV, GG control valve, and check valves.
	0-4 Scim	Flow-check LOX seal cavity and gearcase orifices, when required by replacement.
	0-10 Scim	Leak-check FABU.
	0-30 Scim (Upstream)	Leak-check GG control valve.
	0-80 Scim	Leak-check MOV, IFV, IMV, unitized check valve, and turbopump shaft seals.
	0-200 Scim	Leak-check IMV.
	0-3000 Scim	Leak-check IMV.
	0-5000 Scim	Leak-check turbine seal.
	Heat Exchanger Coil Test Plates	Seal heat exchanger coil during leak-checks.
	Heat Exchanger Shell Test Plates	Seal heat exchanger shell during water submersion test, when required.
	Megohmeter, 500 VDC	Check insulation resistance of electrical components and harnesses.
	Relief Valves, 13 and 35 psig	Prevent overpressurization of TC, turbopump, and gearcase during checkout.
	Flowrator, 0-25 Gallons	Indicate level of TC jacket fuel prefill during prelaunch operations.

Table C-2. Support Equipment for H-1 Engines (Sheet 2 of 6)

Number	Nomenclature	Use
	Balance Scale (0-1000 Grams, Sensitive to Within One Gram)	Weigh hypergol igniter before installation.
	Cryogenic Tank	Submerge unitized check valve in LN_2 during cold tests.
	Dial Indicator (0.001 inch increments)	Determine turbopump shaft axial movement.
	Precision Parallel Bar	For use with depth micrometer to obtain turbopump seal compression and clearance measurements.
	Protective Enclosures	Protect operator during pressure tests.
	Three-Way N. C. Solenoid Valve	Rapidly pressurize IMV control port during pneumatic testing (a manual 3-way toggle valve NA5-11058 is an acceptable alternate).
G3004 or G3104	Pneumatic Flow Tester	Measure leakage during system leak tests.
G4039	Handler Adapter	Support engine in horizontal position on transportation trailer.
G4040	Transportation Trailer	Support engine and handler adapter during transportation.
Model 22-25	Portable Plater (Brooktronics Engineering Corp)	Repair TC tube dents.
Model 5305	Wheatstone Bridge	Measure resistance of TOPS contacts.
Model 630A	Multimeter	Perform electrical continuity tests.

Table C-2. Support Equipment for H-1 Engines (Sheet 3 of 6)

Number	Nomenclature	Use
NA5-11058	Manual 3-Way Toggle Valve	Rapidly pressurize IMV control port and rapidly depressurize MOV closing control port during checkout. (An electric solenoid valve is an acceptable alternate.)
RX-20887	GG Combustion Chamber Seal Assembly	Seal GG combustor and isolate combustor from exhaust system.
S-2-3-25	Accumulator, 20 Cu. In. Capacity Minimum	Provide positive inlet pressure during IMV and FABU checkout.
T-5001167	Turbopump Torque Wrench Adapter	Adapt accessory drive pad spline to torque wrench.
T-5016017	LOX Pump Inlet Test Plate	Seal LOX pump inlet.
T-5020999	Turbine Attaching Nut Torquing Wrench	Remove and install turbine attach nuts.
T-5027946	Pressure Test Fixture	Cryogenic and ambient leak test gas generator LOX injector purge check valve.
T-5028992	Engine Dummy Weight	Proof test Engine Adapter Handler G4039 and Rocket Engine Trailer G4040.
T-5044644	Turbine Snap Ring Removal Tool	Compress snapring on shaft to free turbine for removal.
T-5045425	Rachet Wrench	Remove and install MFV on TC manifold inlet.
T-5045841	Pressure Test Fixture	Seal hypergol container during system leak and function tests.

Table C-2. Support Equipment for H-1 Engines (Sheet 4 of 6)

Number	Nomenclature	Use
T-5045842	Pressure Test Fixture	Seal LOX dome bootstrap port during system leak and function tests.
T-5045843	Pressure Test Fixture	Seal thrust chamber fuel manifold fuel bootstrap port during leak and function tests.
T-5100775	Test Plates	Seal MFV gate housing inlet and outlet during testing.
T-5100778	Pressure Test Fixture (Spool)	Seal MOV gate housing inlet and outlet during ambient or cold testing (provides an LN_2 standpipe for cold testing).
T-5100779	Text Fixture	Adapt IMV outlet port to test setup.
T-5100782	Fixture	Adapt IFV to pneumatic test setup.
T-5100783	Dummy Inducer Tool	Simulate turbopump LOX inducer when obtaining assembly measurements.
T-5100955	Bellows Compression Tool	Compress LOX duct bellows during assembly.
T-5102517	Conax Valve Manifold Test Plate	Replace Conax valve; prevent flow.
T-5102518	Hypergol Container Test Plug (Long)	Plug hypergol container; prevent flow into TC.
T-5102520	Pressure Test Fixture	Adapt GG control valve LOX inlet to test equipment.
T-5102521	Pressure Test Fixture	Adapt GG control valve actuator port to test equipment.

Table C-2. Support Equipment for H-1 Engines (Sheet 5 of 6)

Number	Nomenclature	Use
T-5102523	Conax Valve Manifold Test Plate	Replace Conax valve; simulate fired valve, allow flow.
T-5102524	SPGG Replacement Test Plate	Seal SPGG attach flange on GG combustor.
T-5102539	Fuel Pump Inlet Test Plate	Seal fuel pump inlet.
T-5103792	Lube Overboard Drain Line Pressure Plug	Plug gearcase lube overboard drain line.
T-5104317	Tab Bender	Bend turbopump inducer washer tabs.
T-5104417	Lockwasher Tab Bender	Bend tabs of lockwasher on turbopump.
T-5105437	Pressure Test Fixture	Adapt unitized check valve openings to test setup.
T-8200756	4,200 Pound Proof Fixture	Proof test Rocket Engine Adapter Handler G4039 and Rocket Engine Trailer G4040.
405773	LOX Duct Bleed Port Adapter	Seal LOX duct bleed port during leak-test.
408380	Cover Plate	Seal TOPS opening on gate housing during testing.
43F4-316	1/4-Turn (Full-Open) Valve	Rapidly pressurize FABU inlet during checkout. (An electric solenoid or fast-acting manual toggle valve is acceptable alternate.)
552475, 552513, or equivalent	Test Envelope	Encase lube drain relief valve during checkout.
57508	Check Valve (1/2-inch)	Flush LOX dome.
88-556666	Probe	Leak-test IMV slipper seal and diaphragm.

Table C-2. Support Equipment for H-1 Engines (Sheet 6 of 6)

Number	Nomenclature	Use
9011722	Seal Puller	Remove fuel seal from turbopump cavity.
9014617	Turbopump LOX Seal Cavity Swab	Inspect LOX seal cavity for contamination.
9026002	Inert GG Igniter	Simulate igniter installation.
9026003	Inert GG Initiator	Simulate initiator installation.
9024399	Exhaust Duct Pressure Plug	Seal turbine exhaust exit on H-1C engines.
9026077	Fuel Bootstrap Pressure Seal	Replace fuel bootstrap seal plate and isolate GG from TC. (Delivered with engine.)
9026078	Main Fuel Pressure Seal	Replace main fuel orifice and isolate fuel pump from TC. (Delivered with engine.)
903404-31	Thrust Chamber Throat Plug	Seal TC combustion zone.
906907	Aspirator Pressure Plug	Seal turbine exhaust exit on H-1D engines.
9529-41013	LOX Dome Nozzle	Flush LOX dome.

Table C-3. Support Equipment for J-2 Engines (Sheet 1 of 8)

Number	Nomenclature	Use
EWR 129666	STW Swing Gate Test Plate Gasket	Seal test plate on start tank discharge outlet flange when vacuum drying start system.
EWR 168312 and 168313	Universal Fitting	Replace vent port check valve during vacuum drying MRCV.
EWR 183648	Torque Adapter	Install ECA valve core.
EWR 915725	Split Barrel (Fuel)	Protect fuel turbopump from damage when removing or installing fuel inlet duct.
EWR 915726	Top Plate (Fuel)	Protect fuel turbopump from damage/contamination when removing or installing fuel inlet duct.
EWR 972056	Bottom Plate (Oxidizer Duct)	Protect oxidizer inlet duct outlet flange when duct is removed or installed.
EWR 972057	Bottom Plate (Fuel Duct)	Protect fuel inlet duct outlet flange when duct is removed or installed.
G3104	Pneumatic Flow Tester	Measure leakage during system leak-tests.
G3120	Thrust Chamber Throat Plug Kit	Seal thrust chamber during leak-tests.
G3127	Single Head Special Tool Kit	Used with Automatic Inert Gas Arc Welding Set G3128.
G3128	Automatic Inert Gas Arc Welding Set	Perform in-place tube welding.
G4035	Engine Vertical Installer	Remove and install engine at vehicle stage site.

Table C-3. Support Equipment for J-2 Engines (Sheet 2 of 8)

Number	Nomenclature	Use
G4042	Engine Forward Handling Sling	Lift and rotate engine between horizontal and vertical positions; used with G4045.
G4045	Engine Aft Handling Sling	Lift and rotate engine between horizontal and vertical positions; used with G4042.
G4046	Turbopump Sling	Lift and handle either turbopump during removal or installation.
G4063	Turbopump Rotating Sling	Rotate either turbopump to correct position for mounting on engine or maintenance stand.
G4064	Engine Handler	Support engine after removal from a stage, during transportation, and while in limited storage.
G4071	Engine Components Installer	Remove and install engine components in S-II stage.
G4072	Engine Components Installer	Remove and install engine components in S-IVB stage.
KSC-J2-R066967	Test Fixture	Attach to oxidizer turbopump primary seal drain line for determining leakage.
RL 681000	Spark Igniter Cable Gas Sample Bottle	Sample spark igniter cable pressurizing gas.
T-5044445	Pin Puller	Remove brass plugs from leak detection ports.
9016701	Bypass Test Plate Kit	Seal oxidizer turbine bypass duct during exhaust system leak-testing.

Table C-3. Support Equipment for J-2 Engines (Sheet 3 of 8)

Number	Nomenclature	Use
9016705	Thrust Chamber Protective Pad	Protect TC tubes during maintenance in TC and TC throat plug.
9016710	Hot-Gas Exhaust Test Plate Kit	Seal hot-gas system during system leak-tests.
9016711-21	Turbopump Torque Wrench Kit	Adapt torque wrench to perform fuel turbopump shaft torque inspections.
9016712-11	Turbopump Torque Wrench Kit	Adapt torque wrench to perform LOX turbopump shaft torque inspection when hydraulic pump is not installed.
9016713	Turbopump Inlet Ducts Tests Plate Kit	Seal propellant feed system inlet ducts during system leak-tests when engine is not installed in stage.
9016719	One-inch, 30-psig, Customer-Connection, Test Plate Kit	Seal and provide an inlet fitting for pressurizing heat exchanger helium inlet customer connection.
9016723-11	Bypass Valve Actuation Plate Kit	Actuate bypass valve closed to permit installation of bypass duct test plate. Seal and apply pressure to closing port of OTBV to permit valve removal or installation.
9016724	5/8-Inch, 600 psig, Customer-Connection Test Plate Kit	Provide a fitting for pressurization of start tank vent valve control during sequence check-out and start tank leak-tests.
9016779	Component Handler Universal Sling	Adapt all component handlers for slings.

Table C-3. Support Equipment for J-2 Engines (Sheet 4 of 8)

Number	Nomenclature	Use
9016783-11	Start Tank Installer	Handle start tank during removal or installation while engine is horizontal.
9016784	Fuel Inlet Duct Handler	Compress inlet duct bellows and handle duct used with other lifting facilities.
9016785-11	Oxidizer Inlet Duct Handler	Compress inlet duct bellows and handle duct; used with other lifting facilities.
9016786	Oxidizer Feed System Handlers	Adapt oxidizer feed system components to lifting sling 9016779.
9016787-11	Fuel Feed System Handler	Adapt fuel feed system components to lifting sling 9016779.
9016789	Electrical Control Assembly Handler	Adapt electrical control assembly to lifting sling 9016779.
9016790-11	Oxidizer Heat Exchanger Handler	Compress exhaust duct bellows and handle heat exchanger; used with other lifting facilities.
9016796	Components Adapter Set	Plates and fixtures for component tests. Also, a mass spectrometer with portable test station, a high-potential test set, and a portable liquid nitrogen tank.
9017259	Turbopump Torque Wrench Kit	Adapt torque wrench to perform oxidizer turbopump shaft torque inspection when hydraulic pump is installed.

Table C-3. Support Equipment for J-2 Engines (Sheet 5 of 8)

Number	Nomenclature	Use
9017273	5/8-Inch 500-psig Customer-Connection Test Plate Kit	Seal start tank ground fill connection during start tank leak-tests.
9017274	5/8-Inch, 2,000-psig Customer-Connection Test Plate Kit	Provide fitting for helium fill connection during leak- and function-tests of engine system.
9018840	1-1/2 Inch, 30-psig Customer-Connection Test Plate Kit	Provide fitting for pressurizing GG fuel bleed and hydrogen tank pressurization customer connections.
9018843-11	5/8-Inch, 30-psig Customer-Connection Test Plate Kit	Seal and provide an inlet fitting for pressurizing turbopump, GG oxidizer bleed, start tank vent and relief, and thrust chamber jacket purges.
9018846	Turbine Exhaust Leak-Test Plate Kit	Seal accessory drive pad and fuel turbopump torque pad and provide fittings for pressurizing and monitoring test pressures during system leak-tests.
9019960	Accumulator Hose Plate Kit	Seal disconnected accumulator hose during engine test.
9019968	Heat Exchanger Oxidizer Supply Line Test Plate Kit	Apply vacuum to heat exchanger oxidizer supply line, and vacuum or purge dry start tank gaseous refill line.
9019969	Gas Generator Control Valve Test Plate Kit	Open GG control valve to permit drying bootstrap line, and provide a means to vacuum or purge dry start tank liquid refill line.

Table C-3. Support Equipment for J-2 Engines (Sheet 6 of 8)

Number	Nomenclature	Use
9020266	Oxidizer Tank Customer-Connection Pressurization Test Plate Kit	Seal and provide an inlet fitting for pressurization of heat exchanger oxidizer tank pressurization customer connection.
9020269	Bypass Valve Removal Tool	Move bypass duct flanges apart to permit installation of bypass duct test plate during leak-tests and to permit removal of bypass valve; used with plate kit 9016723.
9020628-51	Fluid Lines Interface Support	Support customer connections (fluid) during engine installation and maintenance.
9020784-11	Oxidizer Dome Purge Shutoff Plug Kit	Seal oxidizer dome purge line during leak-tests of engine pneumatic system.
9020798-11	Oxidizer Turbopump Maintenance Set	Equipment to repair and test oxidizer turbopump.
9020799-31	Fuel Turbopump Maintenance Set	Equipment to repair and test fuel turbopump.
9022985	Start Tank Sling	Lift and handle start tank from installer.
9024496	Oxidizer and Fuel Turbine Drain Lines Test Adapter Kit	Connect oxidizer and fuel turbine seal bleed lines.
9024497	ASI and GG Oxidizer Purge Lines Test Plate Kit	Connect to downstream flanges in ASI oxidizer and GG oxidizer purge and GG oxidizer cavity purge check valves.
9024540	Propellant Inlet Duct Null Adjuster Set	Equipment to adjust propellant inlet ducts torsion bellows to a null position.

Table C-3. Support Equipment for J-2 Engines (Sheet 7 of 8)

Number	Nomenclature	Use
9024994	Insulator Installer Tool Kit	Install insulators on electrical connector pins.
9024997	Thrust Chamber Start Tank Refill Flange Test Plate Kit	Enable correct purging of liquid refill check valve.
9024998	Gas Generator Equalization Line Leak Test Adapter Kit	Leak-test GG control valve vent port check valve boss.
9024999	Flight Instrumentation Pressure Transducer Removal Tool Kit	Equipment for removal and installation of pressure transducers in primary and auxiliary instrumentation packages.
9025145	Vertical Installer and Engine Slings Proof-Test Weight	Proof-load Engine Vertical Installer G4035, Engine Aft Handling Sling G4045, and Engine Forward Handling Sling G4042.
9025146	Turbopump Sling Proof-Test Weight	Proof-load Oxidizer and Fuel Turbopump Rotation Sling G4063 and Turbopump Sling G4046.
9025150	Inlet Duct Support Installer Assembly	Install and remove inlet duct supports for fuel and oxidizer inlet ducts.
9025400	Pressure-Actuated Purge Valve Test Plate Kit	Conserve helium during engine leak-test through installation of plate at inlet port of purge control valve.
9025405	Calibration Pressure Switches Test Adapter Kit	Check mainstage OK pressure switches.
9025419	Fuel Pump Leak and Flow Adapter Kit	Leak- and flow-test fuel seal cavity.

Table C-3. Support Equipment for J-2 Engines (Sheet 8 of 8)

Number	Nomenclature	Use
9025424	Vent Adapter Kit	Conserve helium during engine checkout.
9025425-31	Spark Igniter Cable Pressurization Tool Kit	Leak-test, pressurize, and seal cable assembly.
9025591	Electrical Control Insulation Resistance Test Connector Kit	Resistance-to-ground testing electrical system.
9025817	Oxidizer Turbopump Seal Cavity Drain Line Test Adapter Kit	Adapt to turbopump seal cavity drain line for leak tests.
9025826	Vacuum Manifold	Connections for manifold drying start tank.

APPENDIX D

TERMS AND DEFINITIONS

The following terms and definitions are used on Saturn engine programs and are listed for reference only.

Definition of Terms

Critical Failure (Code #1)	- An unsatisfactory condition that could result in hazard to personnel and equipment.
Major Failure (Code #5)	- An unsatisfactory condition that could result in abort of mission but does not cause hazard to personnel or equipment. This includes conditions that can cause a definite launch scrub.
Minor Failure (Code #6)	- An unsatisfactory condition that does not significantly affect mission success. This classification includes unsatisfactory conditions that could result in information loss when no significant effect on mission operation is concerned, and conditions that could cause a short launch.
Leak-Check	- A check is performed to verify integrity of a pressurized system/component by use of leak-test solution and/or instruments, such as flow-meters, gages, or mass spectrometers.
Functional-Check	- A check is performed to verify functional capability by use of a dynamic source, such as mechanical hydraulic, pneumatic, or electro-mechanical
Torque-Check	- A check is performed to verify that the following torques are within specified limits: a. Breakaway. Torque applied to start rotation. b. Dynamic. Torque applied (to turbopump) to maintain rotation.
Visual Inspection	- An inspection is performed upon receiving and at specific times thereafter, to determine if there is corrosion, excessive moisture, contamination, or damage, and to verify hardware configuration per appropriate records.
Task Verification Inspection	- A quality assurance verification is performed during checkout, maintenance and repair of delivered hardware, as established by the FORR system.

Definition of Terms

Special Inspection	- An inspection is performed resulting from a suspected deficiency of design, manufacturing, contamination, or use, as initiated by an Engine Field Inspection Request (EFIR).
Drying/Decontamination	- Cleanness is achieved and maintained by draining, flushing, purging, heating, and desiccation.
Preservation	- A system or component is prepared for storage through the use of sealing/wrapping, desiccants, covers, and enclosures.
Preparation	- The engine and GSE are readied for checkout or operation by removing protective closures, installing loose equipment, and connecting GSE.
Securing	- The engine and GSE are secured to original configuration by disconnecting GSE, removing expended loose equipment, and installing protective covers and closures.
Handling	- Handling consists primarily of positioning, rotating, and intrafacility transporting.
Scheduled Maintenance	- Planned maintenance events to be performed resulting from hardware activity and hardware design limitations. Maintenance requirements have been established and are defined in the contractor's technical manuals.
Nonscheduled Maintenance	- Unplanned maintenance events that occur resulting from hardware activity and hardware anomalies. Maintenance requirements are determined through design evaluation and maintenance analysis.
Modification	- A modification is a physical change to the equipment resulting from a design change. As used herein, modification includes compliance with retrofit kits and installation of Stage Contractor Hardware.
Calibration	- Calibration consists of the tests and adjustments which determine that an instrument or special tool meets the performance requirements of a given set of standards. Engine calibration consists of orificing propellant flow to provide engine performance with model specification requirements.

Definition of Terms

Alinement	- An operation performed to determine that the location of the geometric thrust vector, with reference to the engine centerline and center of the gimbal block, is within model specification requirements.
Functional Inspection	- An inspection performed during functional checkout to determine that the hardware will operate within appropriate specifications.
Dimensional Inspection	- An inspection performed to determine that hardware size and configuration are within predetermined tolerances.
Engine and GSE Preparation	- Preparing the engine and GSE for checkout or operation and consists of removing protective closures, installing loose equipment, prefilling the thrust chamber, and connecting GSE
Turbopump Preservation	- An operation performed to flush the turbopump gearcase lube system with preservative compound to provide a protective preservative coating on gears and bearings.
Active Storage	- Hardware maintained in a serviceable condition that can be used without qualification.
Short-Term Storage	- Serviceable hardware used occasionally that is processed and placed in storage in a ready or semi-ready state.
Long Term Storage	- Hardware processed and placed in storage for periods exceeding two years.

APPENDIX E

ABBREVIATIONS

The following abbreviations are used on Saturn engine programs and are listed for reference only.

Abbreviations	Item
ASI	- Augmented Spark Igniter
ASTP	- Apollo Soyuz Test Project
CCN	- Contract Change Notice
CDDT	- Countdown Demonstration Test
CEI	- Contract End Item
CM&R	- Component Maintenance and Repair
COC	- Certificate of Completion
CONTR	- Contractor
COR	- Contracting Officer Representative
CTR	- Component Test Record
DR	- Data Requirement
DRL	- Data Requirements List
ECP	- Engineering Change Proposal
EFIR	- Engine Field Inspection Request
EFL	- Edwards Field Laboratory
EID	- Engine Interface Document
ELB	- Engine Log Book
EPO	- Engine Project Office (NASA)
FABU	- Fuel Additive Blender Unit
FAR	- Failure Analysis Report
FLD ENGRG	- Field Engineering
FIDCR	- Field Inspection Discrepancy and Correction Record

Abbreviations	Item
FIR	- Field Information Request/Report
FORR	- Field Operation Requirement & Record
FQAM	- Field Quality Assurance Manual
FQOI	- Field Quality Operating Instructions
FRR	- Flight Readiness Review
FRT	- Flight Readiness Test
FTC	- Florida Test Center
FWV	- Flight Worthiness Verification
GFP	- Government-Furnished Property
GG	- Gas generator
GOX	- Gaseous oxygen
GSE	- Ground support equipment
IDR	- Inspection and Disposition Report
IFV	- Igniter fuel valve
IMV	- Ignition monitor valve
IPB	- Illustrated Parts Breakdown
IU	- Instrumentation Unit
KSC	- Kennedy Space Center
LC	- Launch Countdown
LHR	- Logistics Hardware Release
LIB	- Logistics Information Bulletin
LOM	- Logistics Operating Manual
LOTSI	- List of Time Sensitive Items

Abbreviations	Item
LOX	- Liquid oxygen
LV	- Launch Vehicle
LVO	- Launch Vehicle Operations (KSC/NASA)
MAF	- Michoud Assembly Facility
MCR	- Master Change Record
MD	- Modified Design
MFV	- Main fuel valve
MGT	- Management
ML/LUT	- Mobile Launcher/Launch Umbilical Tower
MOD	- Modification
MOV	- Main oxidizer valve
MSFC	- Marshall Space Flight Center
NASA	- National Aeronautics and Space Administration
NASPR	- NASA Procurement Regulation
OATS	- Overall Tests
O&FS	- Operations and Flight Support
OICN	- Operating Instruction Change Notice
OPN	- Operation(s)
OTBV	- Oxidizer turbine bypass valve
PA	- Program Authorization
PCR	- Procedure Change Request
PCS	- Publication Change Suggestion

Abbreviations		Item
PCCB	-	Program Configuration Control Board
PD	-	Program Directive
POICN	-	Proposed Operating Instruction Change Notice
PSC	-	Post Storage Checkout
PWR	-	Power
QA	-	Quality Assurance
QAI	-	Quality Assurance Instructions
RAPS	-	Rocketdyne Automated Packaging System
REQT	-	Requirement
RFD	-	Request for Disposition
RKDN	-	Rocketdyne
ROCKWELL	-	Rockwell International
ROP	-	Rocketdyne Operating Policies
RSPL	-	Recommended Support Parts List
SAS	-	Site Associated Support
SECT	-	Section
STDV	-	Start Tank Discharge Valve
STE	-	Special Test Equipment
STG	-	Stage
TC	-	Thrust chamber
TIS	-	Thermal Insulation Set
TOPS	-	Thrust OK Pressure Switch
TSC	-	Test Specification and Criteria
UCR	-	Unsatisfactory Condition Report
VAB	-	Vehicle Assembly Building